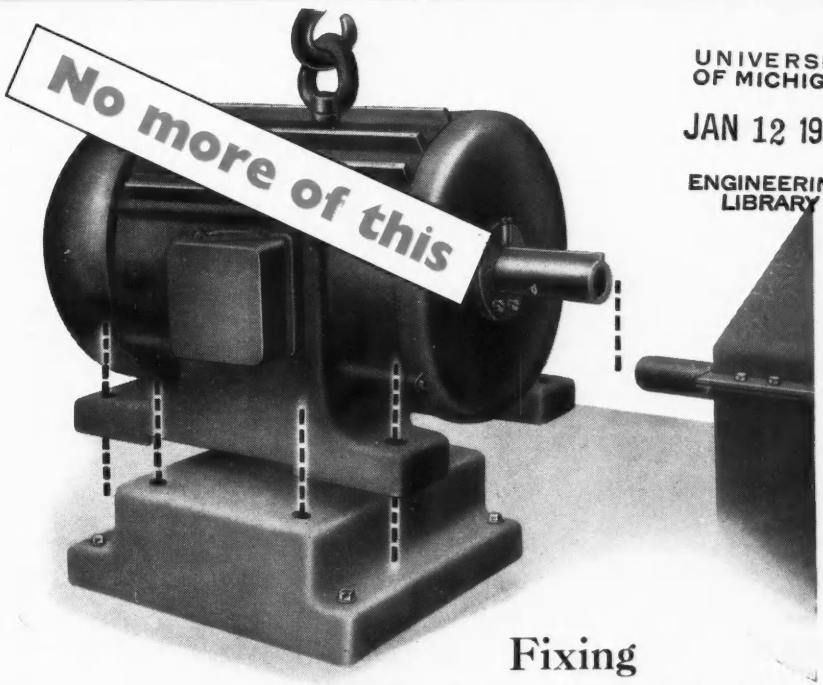
The
ENGINEERS' DIGEST

REVIEW OF WORLD ENGINEERING PROGRESS

VOL. XIV No. 12. DECEMBER, 1953

UNIVERSITY OF MICHIGAN
JAN 12 1954
ENGINEERING LIBRARY



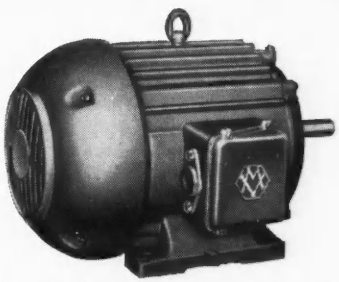
Fixing dimensions standardized

Leading motor manufacturers in this country have collaborated in the design of a range of totally-enclosed fan-cooled, foot mounting, squirrel cage motors having outputs from ¾ h.p. up to 25 h.p. These machines, rating for rating, will all be built to the same leading dimensions which will be laid down in a British Standards specification.

This move to standardize motor fixing dimensions meets a widespread demand and will ensure that when motor replacement is necessary, lost production time is reduced to a minimum.

METROVICK are manufacturing a new range of machines which comply fully with British Standard Draft Specification CN (ELE) 6814. The M.V. range is known as:

TYPE KNB MOTORS



One of the totally enclosed fan-cooled Type KNB motors with standardized fixing dimensions.

METROPOLITAN-VICKERS ELECTRICAL COMPANY LIMITED, TRAFFORD PARK, MANCHESTER 17

Member of the A.E.I. group of companies

METROVICK *motors ready for world-wide service*

HOLDEN'S

SUPERFAST air drying enamel

ONE COAT COVERAGE AT HIGH SPEED

NO PRIMER OR UNDERCOATING
YET OPTIMUM ADHESION

AIR DRYING IN 40 MINUTES
STOVE CONVECTION OVEN
15 MINUTES
INFRA RED 3-4 MINUTES

HIGH RESISTANCE TO
ALKALIES, SUDS
LUBRICATING OILS
SOLUBLE CUTTING OILS
SOLVENT, WATER AND STEAM

Send for sample to:–

ARTHUR HOLDEN & SONS LIMITED
BORDESLEY GREEN RD. BIRMINGHAM, 9.

TELEPHONE: VICtoria 2761 (5 lines)

CONTENTS

	Page
The Blue Pages	449
Machine Tool Trends in the U.S.A.	453
Space Control in a Modern Factory	454
Dust and Fume Problems in the Steel Industry	457
Flow through Nozzles in Rocket Motors	460
The Design of Equivalent Circuits for Electromagnetic Apparatus	463
The Use of Water in Molten Salt Quenching Baths	465
The Ferraris Motor and its Application in Control Systems	467
The New Cryogenic Laboratory of the National Bureau of Standards	471
Non-Corrosive Soldering Fluxes	473
The Influence of Primary Creep on Stresses in Structural Parts	474
New Materials, Processes and Equipment	477
Classified Abstracts	481
News of the Month	487

The ENGINEERS' DIGEST

REVIEW OF WORLD ENGINEERING PROGRESS

VOL. XIV. No. 12 DECEMBER, 1953

EDITORIAL AND ADVERTISING OFFICES:

GREAT BRITAIN
120 Wigmore Street, London, W.1.
Telephone: WELbeck 9357 & 6263

U.S.A.
366 Madison Avenue, New York 17, N.Y.
Telephone: MUrray Hill 2-8865

FRANCE
93 Champs-Élysées, Paris (8e)
Telephone: Élysées 09-03

Annual Subscription Rates:
£2 2s. 0d. in the Sterling area, $7.50 in the Dollar area.

Printed in Gt. Britain by ROBERT STOCKWELL LTD., 5-13 Baden Place, London, S.E.1, and published monthly by the proprietors, ENGINEERS' DIGEST LTD., 120 Wigmore Street, London, W.1.

pitman

Aircraft Engines of the World
By PAUL H. WILKINSON, A.F.I.Ae.S., A.F.R.Ae.S. A standard international reference work giving up-to-date information on all types of engines, accessories, fuels and lubricants. Full-page illustrations of the engines are given opposite the relevant data. 126 illustrations. 50/- net.

An Introduction to Chemical Engineering
By T. K. ROSS, M.Sc., M.I.Chem.E., A.M.Inst.F., Lecturer in Chemical Engineering in the University of Birmingham. 21/- net.
"... should be invaluable to those who have completed a course in physical chemistry, and who are interested in the basic methods of chemical engineering."—ENGINEERS' DIGEST.

Thermodynamics Applied to Heat Engines
By E. H. LEWITT, Ph.D., B.Sc., A.M.I.Mech.E. Fifth Edition. 30/- net.
"... valuable to those seeking an introduction to the more advanced works on thermodynamics applied to heat engines."—ENGINEERING AND BOILER HOUSE REVIEW.

The M.K.S. System of Units
A GUIDE FOR ELECTRICAL ENGINEERS
By T. MCGREEVY, M.Sc.Tech., M.I.E.E. 21/- net.
"... should be of lasting value to electrical engineers and to teachers and students of electrical engineering and physics."—ENGINEERS' DIGEST.

Production Development and Design
By A. W. WILLSMORE. 12/6 net.
"... a most readable and interesting book, which should be read not only by managers but also by all production executives who are interested in taking a balanced view of their manufacturing set-up and its products."—TIMES REVIEW OF INDUSTRY.

Aircraft Engineer's Handbook
This is a new series specially designed for Aircraft Engineers qualifying for "M" (Maintenance) Licences as laid down by the Air Registration Board in the British Civil Airworthiness Requirements (Section L, Licensing).
No. 1. Airframe Structure and Controls, Flying Instruments and Equipment. By W. J. C. SPELLER. Covers the Category "A" Licence. 30/- net.
No. 2. Instruments. By R. W. SLOLEY and W. H. COULTHARD. Covers the Category "X" Licence. 30/- net.

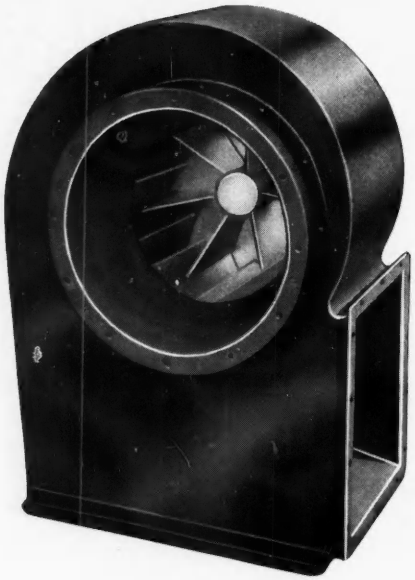
Radioactivity and Radioactive Substances
By SIR JAMES CHADWICK, D.Sc., LL.D., F.R.S. Fourth Edition of this book revised by Prof. J. Rotblat, M.A., Ph.D., D.Sc., F.Inst.P. An excellent introduction both to this special study and to a general study of nuclear physics. 12/6 net.

Faster than Thought
Edited by B. V. BOWDEN, M.A., Ph.D.(Cantab.). A symposium on digital computing machines, giving the history and background of the computer, its theory and design. 35/- net.

The Design of Dams
By A. BOURGIN. Translated by F. F. FERGUSSON, M.I.C.E., F.G.S. 45/- net.
"... an excellent publication, which will prove a useful tool for the expert as well as for the student."—JOURNAL OF THE INSTITUTION OF WATER ENGINEERS.

Solutions of Problems in Strength of Materials
By S. A. URRY, B.Sc.(Eng.), Lecturer in Mechanical Engineering, Wandsworth Technical College. For students preparing for the B.Sc. (Engineering) degree, for the Higher National Certificate in Mechanical Engineering, and for the Associate Membership of the professional bodies. 20/- net.

SIR ISAAC PITMAN & SONS, LTD., *Parker Street, Kingsway, London, W.C.2.*

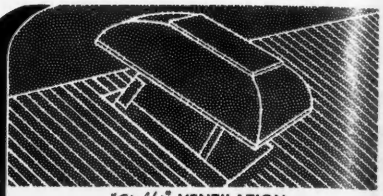


the amazing P.V.C. fan

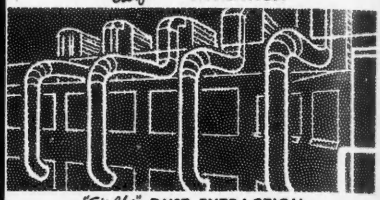
This is the Fan that resists the chemical action of strong acids, alkalis and moist gases — this is the Fan that has provided industry with the greatest step forward in chemical fume handling technique — this is the "Resista" Fan which you should know more about.

You need "Airflo" TRADE MARK equipment

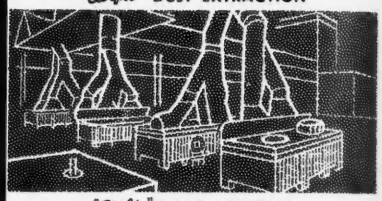
As specialists responsible for some of the largest ventilating and heating schemes in this country and abroad, as well as thousands of small installations, we cover the whole of this industrial field. Our engineers have experience of practically all factory conditions — this experience means that every "Airflo" unit does a 100% job with utmost economy. We invite you to consult us regarding *YOUR* needs now.



"Airflo" VENTILATION

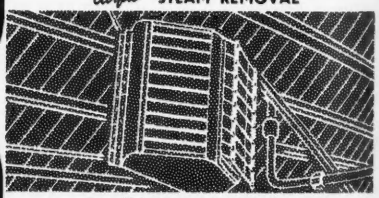


"Airflo" DUST EXTRACTION

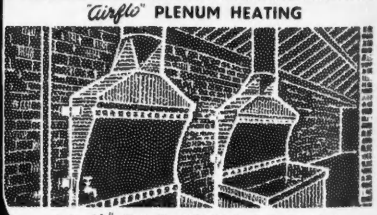


"Airflo" FUME REMOVAL

"Airflo" STEAM REMOVAL



"Airflo" PLENUM HEATING



"Airflo" P.V.C. HOODS & DUCTING

Industrial Fan & Heater Co Ltd

"Airflo" WORKS, BIRMINGHAM, 11 phone: VICtoria 2277

MANCHESTER: CITY BUILDINGS, 69 CORPORATION ST., 4 phone: Blackfriars 6918

G

td

277

6918

GEST

THE BLUE PAGES

A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

● *MASS FLOWMETER*

A new type of mass flowmeter, based on the momentum principle, is claimed to have a number of important advantages over conventional flowmeter types. The new meter develops a linear torque output which makes it easily adaptable to direct reading, remote indication, or control initiation. Another advantage is that it can be installed in any position. It is also reported to possess high accuracy, low pressure loss, small size, and low weight. When testing its accuracy with liquid petroleum fuels of various viscosities and densities, errors did not exceed 0·5 per cent of full-scale indication. The instrument measures fluid flow on a true mass basis. This type of measurement is required in such applications as the combination of reagents in chemical processes, the transportation of different fluids in pipe lines, and the measurement of fuel consumption in aircraft. The design and operating principle of the flowmeter are as follows: The unit consists of two similar cylinders placed end to end, so that the two axes coincide. The instrument housing closely fits the outer diameter of the cylinders. Around the periphery of the cylinders is located a number of passages, the axes of which are parallel to the axes of the cylinders. Fluid passing through the pipe line enters the passages in the first cylinder, proceeds through the passages in the second cylinder and then continues along the pipe line. By driving the upstream cylinder, termed the impeller, at a constant angular velocity about its axis, the fluid is given a constant velocity at right angles to the fluid flow. This angular velocity constitutes a change in momentum of the fluid. The second cylinder, termed the turbine, is designed to remove all the angular momentum from the fluid. In doing so, a torque is exerted on it in accordance with Newton's second law of motion. This torque deflects a spring, restraining the turbine. The angular deflection of the turbine is thus a measure of the rate of mass flow.

● *SELF-BALANCING AUTOMOBILE WHEELS*

A new mercury reactor attachment for automobile wheels is claimed to combine several advantages to give motorists smoother riding comfort. This is accomplished by a set of four discs which can be attached to the wheels of any car. Each of these discs has a number of radially positioned cylinders which contain mercury. These discs are mounted inside the wheel rims around the axle. It is stated that these mercury-loaded discs effectively eliminate the need for balancing weights on car wheels. In fact, weights have never been found fully satisfactory because the balance is lost every time a tyre is changed or a wheel transposed. Furthermore, uneven tyre wear will inevitably upset any fine balance which may previously have been established. The sponsors of the new mercury reactor attachment claim that with the use of this device the wheels of a car will remain constantly dynamically balanced, regardless of other factors. In addition to providing smoother riding, the balancing device has proved in tests to extend greatly the life of the tyres, as these are now made to wear evenly. The tremendous centrifugal force built up in rotating automobile wheels will obviously magnify any existing unbalance and lead to the development of a hammering action. Where a mercury disc is fitted, an equal counter-force will be built up against any existing unbalance and will completely cancel it out. Another important function of the mercury-weighted discs is said to be their vertical shock-absorbing action. The mercury reacts instantly against chatter and shocks due to road roughness before they reach the axles, and thereby saves considerable wear on chassis points. The mercury stabilisers also control lateral action and, since the mercury is free to move from side to side as well as up and down in the chambers, any tendency of the wheels to wobble is countered. Unfortunately, the original report does not mention the size and weight of the mercury chambers nor the way in which the balancing action is carried out.

● *THE OPEN-CIRCUIT THERMOCOUPLE*

Where metal temperatures must be accurately known, it is often found convenient to spot-weld thermocouple wires to the metal in such a way as to make the piece under study act as a part of the hot junction of the thermocouple. This method yields the true temperature of the material and is particularly useful for rapid temperature changes and small sample sizes. In the application of this technique to studies of reaction in the solid state, the individual wires of the thermocouple are spot-welded to a small piece of the material under scrutiny. The validity of such a device is supported by the theories of thermo-

. . . 400 PER CENT DIVIDEND IN THE FIRST YEAR . . .
FIBREGLASS
TRADE MARK
RIGID SECTIONS FOR PIPE INSULATION
REVISED September 1951

400 per cent dividend in the first year : as Fibreglass Rigid Sections are **AVAILABLE FROM STOCK** you can start reaping such benefits at once. Write for our booklet now. An uninsulated 3-inch main, 100 feet long, carrying steam at 400°F wastes fuel at the rate of 13.8 pounds every hour—54 tons in a year of 8,000 working hours. Insulated with Fibreglass Rigid Sections, 2-inches thick (with fixing the cost is about £50) the loss is reduced to 4 tons of coal a year — a clear saving of 50 tons — a sheer gain of £200. Fibreglass insulation is paying 400 per cent dividend in the first year.

FIBREGLASS LIMITED, RAVENHEAD, ST. HELENS, LANCS. TELEPHONE : ST. HELENS 4224

electric phenomena in consideration of the presence of a third dissimilar metal in a thermocouple circuit. When the third dissimilar metal is the sample, as in this "open-circuit thermocouple," the temperature indicated by the thermocouple circuit is a function of the temperature prevailing at the two spot-welded junctions; therefore, it is necessary to have the two junctions at the same temperature. The open-circuit thermocouple will not indicate temperature variations of the material between the spot-welded junctions unless such variations include the area of the junctions. For correct usage, the entire sample between the junctions, and also the junctions themselves, must be kept at the same temperature. With the open-circuit thermocouple substituted for the usual fused-junction type, phase change reactions in metals have been determined in many cases, at temperatures ranging from —40 to +1000° C; there is no reason why the temperature range should not be extended. It would also appear possible to extend this technique to the measurement of temperature and high-speed temperature changes of materials and machines. The operating surface temperatures of components could be measured rather easily without disturbing the continuity of contour of the section, and since the method determines the actual temperature without requiring heat transfer by conduction to a second body, results should be highly accurate.

● *COLOUR EXAMINATION OF CARBIDE MIXTURES*

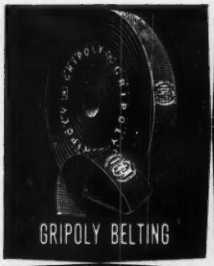
By the employment of a new heat-tinting technique, it is now possible to identify each constituent and phase present in multi-carbide mixtures in colour photo-micrographs at 1500 diameters. It is considered that the new technique will be useful both in straight quality control of carbide cutting tools and in research and development of new carbide compositions. Moreover, there is promise that the heat-tinting technique will clear up some of the reasons for unexplained failures of jet engine blades of the "cermet" type. It is also possible that the new method may shed new light on high-temperature tests by revealing changes in crystal orientation of metals during creep. The polished sample is electrolytically etched with a five per cent solution of sodium carbonate, and rinsed. Next, the specimen is heat-tinted by putting it in a muffle furnace at 900° F for about five minutes. This causes the various phases to take on characteristic colours, which can be photographed in colour. For this purpose the sample is illuminated by a direct current carbon arc lamp. Complete control of the carbon arc is absolutely necessary to maintain the colour temperature of illumination. The colour film used is balanced to utilise the near-ultraviolet radiation in the spectrum of the illuminant. Different glasses in lens components act differently as ultraviolet filters. A two per cent solution of sodium nitrate is added to the water cell to filter out excess ultraviolet radiation. In a basic mixture of tantalum carbide, tungsten carbide, and cobalt, tantalum carbide areas are yellow, tungsten carbide grains are grey, and the cobalt matrix is blue.

● *COMBUSTION CHARACTERISTICS OF ENGINE FUELS*

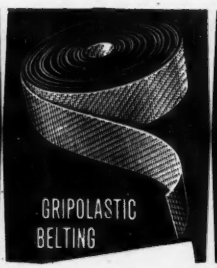
As the compression ratios of modern petrol engines are continually raised, increasing difficulty is being caused by knock and pre-ignition. The rapidly expanding use of diesel engines has also emphasised problems of cold starting, engine roughness, and smoking under heavy-load operation. All these difficulties are associated with the combustion phenomenon known as auto-ignition, which occurs when a fuel-air mixture is heated by compression until it ignites spontaneously. Investigation of many pure hydrocarbons, isooctane-n-heptane blends, and oxygen-containing compounds has shown that, as octane number and resistance to auto-ignition increase, the temperatures at which peroxides and cool flames are first detected also increase, while the amount of heat released during the cool flame decreases. Over a wide range of fuel-air ratios, however, the temperatures at which hot flames first appear lie in the same temperature range of 1100° F ± 50° F of all aliphatic compounds studied. Because the octane numbers and auto-ignition resistances of the fuels studied in a recent investigation vary widely, these properties are believed to be functions of the extent of "self-heating" in the early stages of the reaction. According to this view of the overall process, a very high-octane fuel must be heated by compression alone to nearly 1100° F before hot flames begin to appear, whereas a low-octane fuel may contribute several hundred degrees of the required temperature rise by its own early reactions. Thus, the ease with which low-octane fuel auto-ignites is probably due to the large contribution of the cool-flame reactions in raising the mixture temperature to the necessary 1100° F.

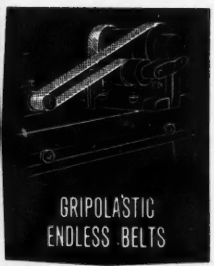
● *MAGNETICALLY BALANCED SCALE*

The balancing force resulting from the interaction of a magnetic field of a solenoid with the field of a permanent magnet can be used to convert a conventional laboratory balance into an automatically continuous weight recorder. The magnet is suspended inside the solenoid at one end of the balance. Automatic balancing occurs when a beam of light from a photoelectric sensing element is reflected to a dual phototube from a mirror mounted on the scale balance beam. The two sections of the phototube are connected in a bridge circuit, the output of which is amplified and applied to the solenoid. Any change in weight


GRIPOLY BELTING

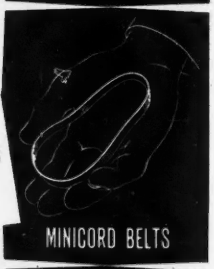
GRIPOLATA RUBBER AND CANVAS PLY BELTING


GRIPOLASTIC BELTING


GRIPOLASTIC ENDLESS BELTS

DURACORD BELTS

There is a GRIPOLY PRODUCT for every POWER TRANSMISSION application

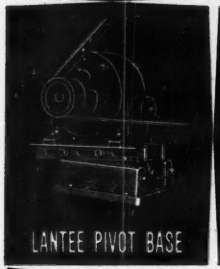

MINICORD BELTS

LANTEE VEE BELTS & PULLEYS

LANDT MILLERS' WEBBING

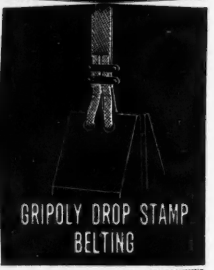
LEATHER BELTING

LANDT BALATA BELTING


LANTEE PIVOT BASE

CONVEYOR BANDS & COMPLETE CONVEYORS

GRIPLACE & OTHER BELT FASTENERS


GRIPOLY DROP STAMP BELTING

Manufacturers of Gripoly Products

LEWIS & TYLOR LTD

Power Transmission Engineers

GRIPOLY MILLS • CARDIFF

FREE!

Write officially for your free "Gripalculator" which facilitates calculations of Belt Drive details.

And at
Griffin Mills, Farnworth, Lancs.
Terminal House, Grosvenor Gardens, London, S.W.1. Branches and Agencies everywhere

tending to produce unbalance is counteracted by whatever change of solenoid current is required to maintain the balance. An electronic damping circuit avoids oscillations and enables the electrical output of the instrument to follow rapid changes in weight. The record of weight changes is obtained by connecting a resistor in series with the solenoid and applying the voltage developed to a recording potentiometer. Since the balancing force exerted on the magnet is directly proportional to the current through the solenoid, the weight scale is linear and the recorder can be made to read directly in, say, milligrams. To avoid oscillation about the equilibrium position, both viscous and magnetic damping were tried successfully. However, a simple modification of the circuit provided a more convenient method of velocity damping. This velocity-damping circuit senses the rate at which the unbalance signal is changing and applies to the solenoid a component of the current proportional to this rate. The result is a braking force which is proportional to the velocity of the beam and which can be adjusted to damp the beam oscillations.

● *SELF-SEALING GATE VALVE*

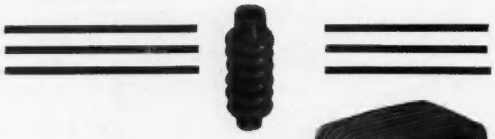
A recent development report discusses the types of high-pressure steel valves used in the petroleum industry. The author traces the development of these valves and analyses the various methods of valve sealing employed in all such valves. Detailed consideration is given to the design of an automatic self-sealing gate valve, and the theory, development, and performance of the valve are examined. The salient engineering features of the new valve-sealing system are as follows: Each valve contains two complete and independent sealing systems, which seal tightly in either direction. Two free-floating and non-wedging gates are in continuous wiping contact with the seats in either open or closed position. This prevents gate leaks due to distortion under pressure and temperature. A sealing groove is machined on the face of each seat encircling the conduit and is connected to the sealing-compound reservoir by a cross-over in the gate. Movement of the gate from the closed position cuts off the sealing groove from the reservoir, preventing washing of the sealing compound downstream. A second sealing groove is placed in each seat to seal off leaks between the pressed-in seat and the valve body. This groove is connected directly to the reservoir. The non-wedging, floating gate arrangement results in maximum ease of operation, and a " cheater " or gear operator should never be necessary on this type of valve, it is claimed. The enclosed reservoirs, which are disconnected from the sealing system except when the valve is closed, result in a large number of operations, before refilling with sealing compound is required. Field experience is reported to indicate that 40 to 80 operations are necessary to exhaust the valve, depending on the fluid and the velocity of flow prevailing. This feature results in a small annual consumption of expensive valve-sealing compound and reduces the cost of valve servicing. In most applications, semi-annual servicing may be expected to give satisfactory performance.

● *ELECTRONIC VALVE WITHOUT HEATING FILAMENT*

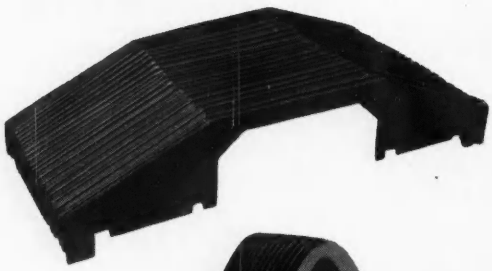
There is hardly any doubt that the need for electronic valves which do not require heating elements is growing steadily. As the various electronic circuits have become more and more complicated and as the demand for smaller units has increased, the problem of heat dissipation has become increasingly important. Furthermore, with greater demand for mobile electronic equipment, a reduction in the power requirements for operating the circuits has also become desirable. Since the heating of filaments takes considerable current, the desirability of eliminating the need for such heating and thereby reducing the power required is readily apparent. A recent invention envisages an electronic valve which contains a pair of electrodes, made, for example, of nickel and coated with an ionic crystalline material, such as a mixture of barium, strontium, and calcium carbonates. These electrodes are positioned in such a manner that they butt against each other so that their coatings are in contact along one side of each electrode. Tungsten wires are sandwiched between these electrodes and are also coated with an ionic crystalline substance. A valve of this type has been found to be effective as an amplifier at room temperature, i.e., without heating any of the electrodes, and therefore without the aid of any filament heater. The electrodes may be used as cathode and anode respectively, and the probe wires as a grid; alternatively and preferably, the electrodes are electrically connected together and used as a cathode, one of the two probe wires serving as anode and the other as a grid. It is stated that excellent results are obtained with a valve of this type; with anode voltages between 10 and 40 volts, amplifications of between 30 and 50 are possible.

● *POWDER CUTTING*

Powder cutting was conceived and developed as a method of progressively cutting stainless steel. Stainless steels normally resist oxygen cutting because of the refractory nature of the chromium oxide layer which forms immediately when stainless steel is heated in the presence of oxygen. The addition of iron powder to such a reaction prevents the solidification of refractory oxides through the generation of additional heat and a fluxing action of iron oxide on chromium oxide. Initially, powder-cutting apparatus was designed so that the powder was introduced into the oxygen stream at some point within the nozzle.



KEEP OUT DIRT with *FORTOX* FLEXIBLE DUST EXCLUDERS



New type construction gives a compact guard with an exceptional expansion, having a ratio of approximately 10-1. All shapes and sizes are available to meet individual requirements. Minimum internal diameter is 1 in. . . . no limit to maximum size. Prototype and development work a speciality. Mechanical Leathers of all descriptions.

HENRY BEAKBANE LTD

HEAD OFFICE AND TANNERY
THE TANNERY
STOURPORT ON SEVERN
WORCS.
TEL. STOURPORT 17

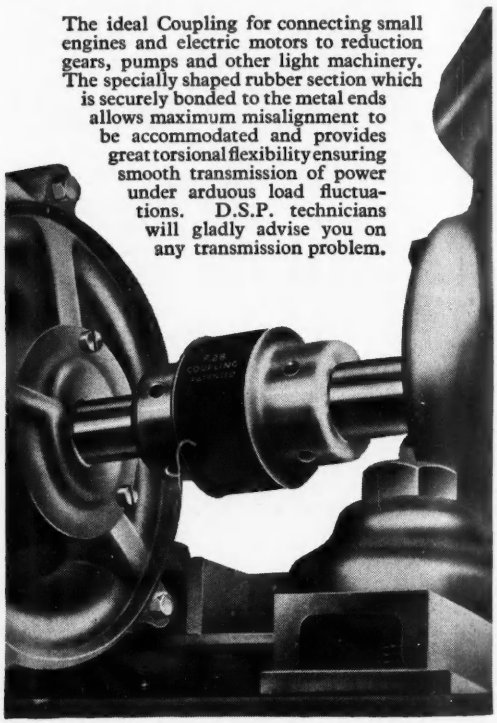
LONDON WORKS
68-70 LANT STREET
BOROUGH, S.E.1.
TEL. HOP 0458

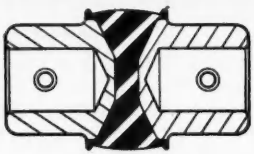
DSP

BARREL TYPE *Flexible* TRANSMISSION COUPLINGS

FOR DRIVES UP TO 0·54 H.P. PER 100 R.P.M.

The ideal Coupling for connecting small engines and electric motors to reduction gears, pumps and other light machinery. The specially shaped rubber section which is securely bonded to the metal ends allows maximum misalignment to be accommodated and provides great torsional flexibility ensuring smooth transmission of power under arduous load fluctuations. D.S.P. technicians will gladly advise you on any transmission problem.





SPECIALISTS IN PRECISION RUBBER ENGINEERING

Dunlop Special Products Limited · Engineering Components Division
Fort Dunlop, Erdington, Birmingham, 24.
Telephone : **Erdington 2121 Extension 341 & 767**

3SPC/PC.3.

Nevertheless, the development of the present method of introducing powder externally has made it possible to operate powder nozzles closer to the work surface. In external powder feed, the air-conveyed powder is directed through preheat flames, where it is raised to ignition temperature and enters the oxygen stream at a point close to the tip of the nozzle. Since all the heated powder particles are ready to start burning as soon as they reach the oxygen stream, the nozzle can be located closer to the work surface than was possible in the old method. This results in faster cutting speeds, reduction in the amount of powder required, and a lower rate of conveying air flow. Powder cutting can also be used in the cutting of copper, nickel, "Hastelloy" brass, and even firebrick. Reinforced concrete has also been cut by the powder process. In the removal of some concrete piers, approximately 14 by 30 inches, it was found that each required several hours of pounding with a heavy jackhammer. The powder cutting equipment was mounted on a machine in a position to make horizontal cuts and it was found that a section 14 inches thick could be penetrated at a progressive speed of $1\frac{1}{2}$ in. per minute, so that only 20 minutes was required for complete cutting of each section. Higher temperatures were obtained by adding aluminium to the iron powder.

● *INCREASING FATIGUE STRENGTH OF CAST IRON BY SURFACE ROLLING*

It is well known that cold working the surface of steel shafts by rolling has a beneficial effect on their fatigue properties, but very little information is published on the subject. In a recent investigation, fatigue specimens with a 45-deg. V-notch, with a root radius of 0·25 mm, were surface-rolled between hardened steel rollers held in a frame. This treatment was found to have a favourable effect on their reversed bending fatigue properties. A moderate pressure which did not result in an appreciable change in notch dimensions was found to give the best results. The fatigue strength of a pearlitic flake graphite iron, calculated on a basis of 20 million stress reversals, was increased by 20 per cent. At higher rolling pressures the fatigue limit decreased, until at high pressures it was the same as for unrolled specimens. The most significant effect of surface rolling on the fatigue properties of cast iron is the very great increase in life obtained at stresses above the fatigue limit. However, the optimum increase was ascertained at the rolling pressure which gave the highest endurance limit. The service life of many components is limited by factors other than fatigue, and it is not always necessary to design at stresses below the fatigue limit and to allow for infinite life in fatigue. In such cases, rolling will have a very beneficial effect, since it will allow much higher stresses to obtain than would be safe in an untreated material. A rolled component, subjected to bending fatigue, will also be able to withstand occasional high overstresses which would quickly cause failure in an untreated component. The improved fatigue properties obtained by surface rolling may be due to any of the following factors :—(1) Compressive stresses are induced in the surface layers ; (2) the surface layers are work-hardened ; (3) the graphite flakes are favourably distributed in the surface layers, resulting in improved tensile properties.

● *CORROSION-RESISTANT ALLOY COATING*

A unique corrosion-resistant coating, which is claimed to impart the protective advantages of stainless steel to common ferrous compositions, has been developed. The new patented process employs phosphorus which, when alloyed with metallic constituents in fairly large percentages of the total composition, greatly reduces the melting point and increases the fluidity of the alloy combination. Thus, the melting point of nickel is brought down from 2640° F to about 1600° F, permitting application at moderate temperatures with good alloying and bonding to the base metal. Basic materials for this process are nickel oxide and various phosphorus compounds, which are applied much like a paint to the surface of the base metal to be treated. These materials are easily available and are of relatively low cost. The mechanism of producing the alloy is one of reduction under heat, whereby metallic nickel and phosphorus are produced. In this reduction, advantage is taken of the fact that ammonium acid phosphate salts decompose in a reducing atmosphere at elevated temperatures to form phosphine, water vapour, free ammonia, hydrogen, and nitrogen. Reducing gases, along with liberated hydrogen, produce a metallised form of nickel from the oxides. Simultaneously, phosphine reacts with nickel oxide and nickel to form metallic nickel phosphide. Since rather small amounts of phosphorus alloyed with nickel greatly reduce the melting point of the combinations, there results a wettable and flowable coating at the temperature at which the operation is carried out. The reducing temperature range is 1550 to 1700° F. This is the usual normalising range for steels and, therefore, excessive grain growth will not occur. Where vessels are too large to be treated by a regular furnace operation, an alternative method comprises spraying of the nickel-phosphorus alloy directly onto the surface to be treated.

For further information on developments reviewed in THE BLUE PAGES, readers are invited to write to the Editor.

Warwick Castle

Shakespeare's Warwickshire—The Cradle of

CRAFTSMANSHIP

MATRIX

Supreme the World over

MANUFACTURERS OF

MACHINE TOOLS . PRECISION INSTRUMENTS AND GAUGES

PRECISION TOOLS OF ALL TYPES

COVENTRY GAUGE & TOOL CO. LTD.

COVENTRY, GT. BRITAIN

1. No. 58 AERO TURBINE BLADE ROOT-FORM GRINDER
2. TAPER DIAMETER MEASURING MACHINE
3. BROACHES

Cogent

THE ENGINEERS' DIGEST
REVIEW OF WORLD ENGINEERING PROGRESS
VOL. XIV. No. 12. DECEMBER, 1953

Machine Tool Trends in the U.S.A.

MACHINE tools are no longer designed merely for the purpose of removing metal. They must now remove it in the least possible time, over the longest possible machine life, and with the greatest possible accuracy. Furthermore, they must remove the metal with the least possible operator effort and at the lowest possible unit cost.

Naturally, machine tool users are interested in all these factors when purchasing a machine but, although all areas must be explored, it is inevitable that sometimes concessions must be made in one area, so as to gain in another.

The question of maintenance is also of primary interest. The service and repair of a machine tool become important factors in its successful application. The machine must be rugged enough to withstand use without breaking down; even more important, the machine must be designed so that those parts which are subject to failure are accessible and capable of easy repair. Moreover, no matter how complicated an operation may be, the mechanism for performing it must be as simple as possible, so that repairs can be effected without the aid of special service men.

In an effort to study trends in machining capacity, methods, tooling, and machine tools, an interesting survey has recently been conducted by the American magazine, *Steel*,* which reveals the preferences of buyers for machine-tool features and checks the types of machine tools in use in the U.S.A. This survey reflects the practices and ideas of 2104 companies who responded to their detailed questionnaire and provides a fair cross-section of the 14,334 metalworking plants performing machining operations in America, and operating nearly 2,400,000 machine tools. In this connection, only companies with twenty or more employees are included in the survey. While the companies employing more than twenty account for less than half the total number of metalworking plants, they represent more than 96 per cent of the industry's total employment and its total dollar volume of business.

The survey reveals that seven out of eight companies expect to increase their machining capacity during the next six years, these anticipated increases being remarkably uniform through all sizes of plants.

The chief influence in the decision to buy machine tools rests with the company's president, with the superintendent a close second. However, the president's influence tends to diminish, as the size of the company increases, while the influence of the superintendent and the works manager, substantial in the smaller companies, increases with company size. Tool engineers, foremen, and master mechanics are cited by the smaller companies as having influence on machine tool purchases, while purchasing agents apparently exercise a substantial influence throughout the range of companies.

Adequate machine tool replacement programmes are major, but unsolved, problems for most companies covered by the survey. Indeed, even among the largest companies, with 1000 or more employees, less than half have planned replacement programmes. The difficulties most frequently mentioned in setting up these programmes include such items as heavy tax burden, long amortisation periods, and inflation.

We extend to all readers our best wishes for a Happy Xmas and a Prosperous New Year

Comparisons of the types of machines tools in use with those it is intended to buy as a result of future expansion, reveal some interesting trends :—Three out of five machining plants intend to buy more lathes. The heaviest expansion will fall in the engine-toolroom classification. Nearly half of all plants doing machining intend to increase the number of their grinding machines. Many of these will be tool and cutter grinders, though all categories are included. More than half indicate an intention to purchase boring and drilling machines. A significant factor in this connection is the almost even split among all types of machines. In addition to contemplated expansion in many quarters, there will also be a rising trend towards buying new machines to replace old and obsolete machines.

Insofar as machine tool features are concerned, nearly all companies are increasingly interested in rigidity. There is a strong demand for more rugged bases and columns, while nearly all

(*Continued on page* 486)

*Section 2, Vol. 183, No. 20, November 16, 1953.

Space Control in a Modern Factory

FACTORY space can be substantially " stretched " by the installation of more efficient machines and the development of more ingenious methods. For instance, the Ryan Aeronautical Company has recently installed at their California plant six new gap lathes, in order to cut in half the machining time on jet exhaust cones, and to save valuable factory space. Because the new lathes will machine both ends of the cones in one set-up, they have eliminated the space formerly needed to store a dozen big cones at each machine between set-ups.

Particularly important to the effort to save space at the Ryan plant is that phase of production concerned with parts handling. Admittedly, their fast roll spot-welding machines, which can weld afterburners in less than half the time of former machines, are impressive tools ; few, however, realize that such savings can be lost in the confusing shuffle of parts handling if the same imagination, devoted to the utilisation of new machines, is not given to production flow and layout problems.

Ryan's objective is to absorb the largest volume of business which the plant's facilities can handle, or, in other words, to put factory space, tools, and manpower to the most economical use. This would be a good deal simpler if the Company were building a single product in mass production, such as water heaters or refrigerators. In such a case, it would be easy to determine what the yield from factory space should be, and to control that yield over a prolonged period, from flat sheet stage to finished product.

In fact, however, the Company manufactures three basically different types of products and operates as both main and sub-contractor. One division builds aircraft and large airframe structures of aluminium, such as Boeing fuselages and fuel tanks, which require considerable space allocations and substantial application of small hand tools. Another division fabricates stainless steel parts for jet engines, which demand an array of big machine tools and furnaces, owing to their high precision specifications. Still another division builds aircraft exhaust systems, which must be shuttled back and forth between innumerable forming, welding, heat treating, and machining operations because of the temperamental behaviour of the alloys used.

With many of the products, the Company does not control the design but must manufacture to a customer's drawings. As a result, they are frequently called upon to modify the design in production to meet ever-changing developments in aerodynamics and metallurgy. Also, production runs are relatively limited in the aircraft industry and the extent of a contract cannot be forecast far into the future.

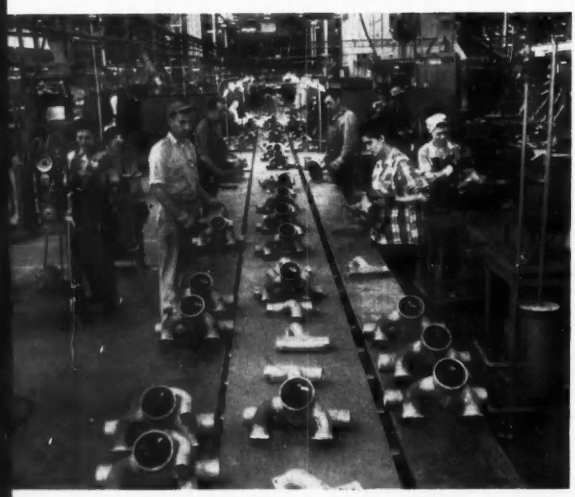


Fig. 1. **Motorised conveyor belt for exhaust systems of tank engines.**

Because of these factors, plant layout must be flexible and must provide parts-handling methods which are streamlined to meet each type of fabrication. These handling methods are, in order of increasing efficiency :

(1) Stock boxes and pallets.
(2) Mobile dollies and special racks.
(3) Conveyors on floor tracks.
(4) Roller conveyors and monorails.
(5) Powered conveyor systems.
(6) Special loading devices.

The first five of these methods are employed to convey parts between production stations. The last category covers innovations used to load and unload parts into and from machines.

In reaching for the maximum dollar return per square foot of floor space, three basic questions relative to each project are considered :—(1) *Rate of production* (how fast must the parts be made ?) ; (2) *production potential* (what is the life expectation of the programme ?); and (3) *type of product* (what are the precision requirements, size, or special features of the product ?)

With this information, flow charts, to determine the manufacturing sequence required, can be made, and the type and number of facilities needed and the layout can be determined. A final recommendation, accompanied by cost estimates, is submitted to top management for approval. Usually, one or two alternative proposals are also submitted.

The key to the development of efficient parts-handling systems is volume. The fascinating possibilities gleaned from conveyorised lines and automatisation can be realized only if parts volume is sufficient to justify the higher costs of these methods. In each section of production, the parts-handling system is tuned to the economic factors governing the project and, consequently, the techniques are quite varied.

For example, Ryan builds thousands of exhaust systems for the engines of General Patton tanks along a straight-flow production line, which is fed with a 140-foot powered conveyor belt, as shown in Fig. 1. Because of the high parts volume, it is possible to use this method on parts handling and save forty per cent of the space otherwise required, through the elimination of room for parts dollies. All production machines can be spaced close together along the flanks of the belt line.

This technique has also doubled production, with slightly more facilities, because the conveyor provides a ready bank of parts in a uniform, accessible flow. Personnel fatigue is lessened, since employees are relieved from carrying parts and can devote their efforts to the production tasks. Another positive benefit is the balanced control of manufacture which a straight line permits. Every part must move to the next station and failure to do so becomes clearly evident. None can be lost in back-tracking or can be shunted to one side in confusion.

To adapt a straight-flow production layout to a project requires not only high volume but also extra machine facilities. Since parts are not permitted to back-track in their travel, added equipment must be stationed along the line to perform every operation. Inevitably, some of these machines will have to be operated at low load factors, depending upon their function, line speed, and so on.

In the case of smaller, less expensive equipment,

Fig. 2. **Roller conveyor production line for inner combustion chambers of jet engines.**

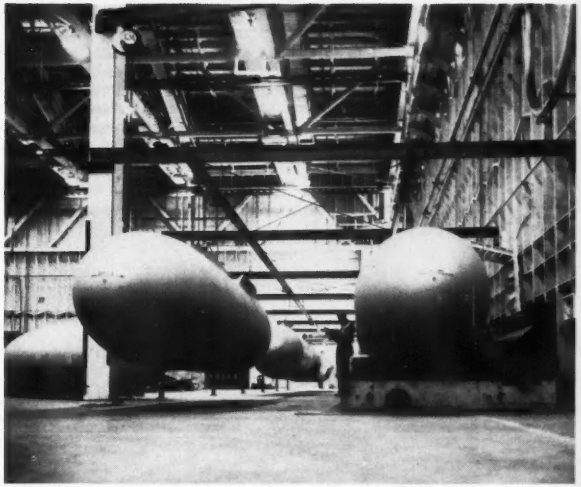


Fig. 3. **Overhead monorail conveyors for handling of large aircraft fuel tanks.**

this sacrifice can well be made in the interest of the stepped up overall efficiency which the straight line system provides; however, in the case of large, expensive machines, careful scrutiny of the relative gains and losses must be made before a decision is reached.

Some products of the Company, such as the inner combustion chambers of jet engines, are made under both "batch" and production line systems. The tough, Inconel cylinders are blanked, coined, and louvred in the forming department, where batch lots are sandwiched between other Ryan components. Then, they are fed to a production line which is served by roller conveyors, and aligned, spot-welded, seam-welded, inspected, and boxed for shipment from the end of the conveyor line (Fig. 2). The conveyor saves space, reduces personnel fatigue, and maintains the units in proper sequence between stations.

Another type of roller conveyor system is employed to handle the Company's fuel tanks, designed for Boeing B-47 Stratojet aircraft. In this instance, the handling method is dictated largely by the requirements of processing. These large containers must be spray-painted, air-dried, sanded, and inspected as well as transferred from one area to another. Therefore, an overhead monorail system, as shown in Fig. 3, was selected to move the cells through the closed, pressure-ventilated spray booth and the drying and sanding areas. This method makes all surfaces of the big tanks accessible for processing and provides a satisfactory way to move them down the line with little effort. Also, since the tanks are bulky and require extended time for drying, this innovation serves a dual purpose as a temporary storage facility, with handling kept to the minimum.

The need to meet the stepped up demands of the Pratt and Whitney Aircraft exhaust systems project, required a somewhat different approach. Each exhaust system for the Wasp Major engine is composed of seven large, stainless steel sections, which are slightly different in design but similar in appearance. They are too big to be picked up and handled easily or placed upon a belt conveyor. A basic problem was the difficulty in differentiating between the similar sections, and maintaining a balance of production so that complete engine sets would come off the production lines for shipment.

By using a specially designed layout, the Company has increased the volume of this work, improved employee morale, enhanced parts quality, and saved fifty per cent of the space otherwise required. The layout was broken into four contiguous areas and each was circled with floor tracks and served with mobile parts dollies, as illustrated in Fig. 4. Special racks were located at strategic points and both racks and dollies were keyed to the various production machines. The racks automatically count the parts produced and give visual evidence of out-of-balance conditions. Space is saved by bringing all machines together within the areas and by using the dollies to convey parts. Added space is conserved by suspending the spot-welding machines overhead and placing the heavy alignment fixtures on wheels and tracks. These converge into central turntables, so that they can be rotated under the spot welders, to make all parts of the fixtures available.

Employee morale is stimulated because the well-defined flow lines of the system prevent similar parts from being mis-routed. Workmanship is enhanced because any error shows up at the subsequent station when the part is checked. A unique method of using

Fig. 4. **Tracked fixtures and turntable for exhaust manifolds of aircraft engines.**

roving crews, who perform one task at each of the seven fixtures in a production area, has increased employee skill by contributing to greater specialisation of labour.

Tracks and mobile fixtures have been used to excellent advantage in the fabrication of external fuel tanks. It takes four men to lift the sections of these tanks and more than 30,000 spot welds are used to join them together. The handling system is designed to save manpower and space in bringing the containers to the big spot-welding machines and positioning them during the welding process.

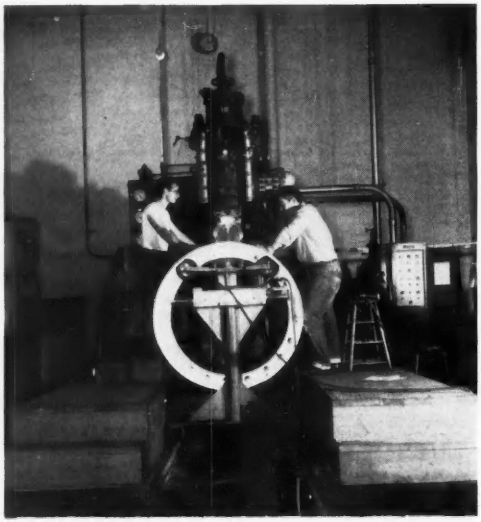


Fig. 5. **Spot-welding machine for the manufacture of external fuel tanks.**

From the centre of the factory, individual sets of tracks were laid to each of the eight spot welders. By means of overhead electric hoists, the heavy tank sections are loaded on special wheeled fixtures which travel on the tracks. Designed to bring the tank seams into the electrode " jaws " at the correct height, these fixtures are rolled to the machines (Fig. 5). The tanks are free to rotate on rollers as welding takes place. At the rear end of the fixtures, a factory-designed hydraulic cylinder actuates the tank alignment. By means of a hand-lever, the machine operator can control tank alignment, so that straight seam welds may be made over tapered tank sections. This layout has saved both direct and indirect manpower. One man can perform all loading, conveying, positioning, and unloading operations instead of the four men who would otherwise have to be on hand.

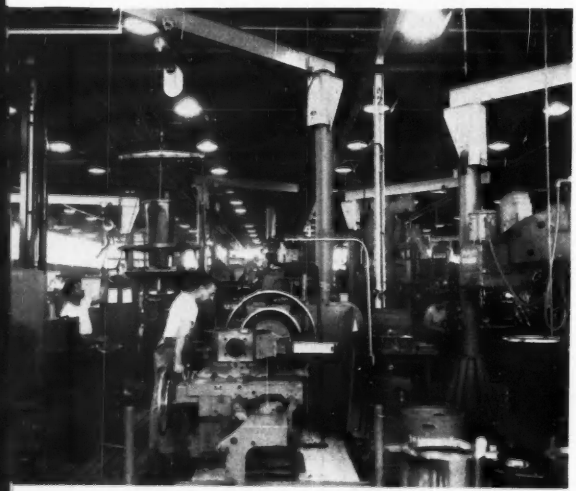


Fig. 6. **Part of jet assembly building, showing pneumatic hoists for loading and unloading machines.**

Among space and time-saving devices, the mechanisms used for loading and unloading machines rate high in effectiveness. This is especially true in the jet-engine building, where large frames and afterburners must be loaded into machines and furnaces.

The company has installed a system of swinging cranes equipped with pneumatic hoists at every strategic location. These devices are surprisingly compact, consisting of a vertical tubular steel column, bolted to the floor, and a swinging steel " I "-beam arm, as shown in Fig. 6. Free to roll back and forth on this arm is a tiny air-motor chain hoist. These cranes are capable of handling components up to 2000 lb and are quite responsive to delicate control. Often, one hoist is located to serve one or more machines, and by its aid, one man can load a furnace car or big lathe with little effort and without help from other employees.

Several ingenious loading devices are used to load heavy trays of jet engine parts into Knapp annealing furnaces. Specially designed steel, grid-type conveyors, hydraulically moved into the furnace, are used. Raised rails carry the trays back and forth. This system also shunts the trays to either side of the loading area, so that the furnace can be unloaded and reloaded with a single opening of the door.

These mechanisms save manpower but, most important, they allow the furnace operators to stay on the job by removing them from the hot blast of the open furnace. With push-button controls, the operators can work at a safe, comfortable distance. Heat lost through open furnace doors is kept to a minimum by the rapid action of the loading devices. If a quick quench following heating is prescribed, the loader is a positive means for meeting requirements.

With certain aluminium alloys, it is necessary to heat the metal to 925° F in a molten salt bath, then quench it in cold water. This strengthens and hardens the metal. To obtain maximum strength, the hot metal must be quenched within 10 seconds after removal from the molten salt bath. For this purpose a large conveyor has been designed, which is operated by a variable-speed motor, with brakes, and a chain drive. Damping devices are used to prevent the conveyor basket from swaying as it moves. In operation, the conveyor slowly removes the parts from the hot bath, speeds them along a horizontal path to the water quench tank, and gently lowers them into the cold water. This is accomplished in less than ten seconds.

To transfer parts throughout the factory as easily as possible, a variety of specially designed racks is in use. These carriers are made of welded steel frames, with padded separators built to fit each type of part, and are equipped with large wheels for easy movement.

By designing the racks for the parts, it was found that a great many more components could be accommodated than with the standard " tote " boxes. For instance, 204 jet engine struts can be carried in one mobile rack which takes little more space than the old type boxes carrying only forty struts. Another typical rack neatly contains thirty combustion chambers, in contrast to the nine which could be placed in an ordinary box.

These racks make better use of factory space by virtue of their storage capacities. The parts are kept in better condition because they are separated and not shuffled together, while personnel prefer them because they are easier to push, load, and unload.

Dust and Fume Problems in the Steel Industry

By R. F. O'Mara. (From *Iron and Steel Engineer*, Vol. 30, No. 10, October, 1953, pp. 100-106, 5 illustrations.)

The U.S. steel industry has made tremendous strides in attacking the problem of air pollution. This article, from one of a number of papers in an Air Pollution Symposium, deals with some current problems and their solution in an industry in which dust recovery plays an ever-increasing part.

There are three main reasons for the use of dust and fume recovery apparatus, namely :—

(1) The cleaning of valuable waste gases from blast furnace and coke ovens so that these gases can be profitably used.

(2) The provision of air for :
  (a) Protection of personnel.
  (b) Protection of equipment.

(3) Nuisance abatement.

In the overall operation of a typical steel plant, there are approximately twelve major areas in which some form of dust or fume control equipment has an application. These are shown in Table I.

Table I.—Present and possible future applications of gas and air cleaning equipment in steel plants are indicated by points.

		Settling Chambers	Large Dia. Cyclones	Multiclones	Wet Scrubbers	Cloth Filters	Electrical Precipitation: Heavy Duty: Film Type	Electrical Precipitation: Heavy Duty: Dry Type	Electrical Precipitation: Light Duty	Miscellaneous Filters
1	Raw Materials Handling									
	(a) Ore			●		●				
	(b) Coal			●		●				
2	Coal Crushing and Preparation		●	●	●	●				
3	Coke Ovens									
	(a) Coke Oven Gas						●		●	
	(b) Coke Screening Plant		●	●	●					
4	Blast Furnace Plant									
	(a) Basic Iron Furnace	●		●	●		●	●		
	(b) Ferromanganese Furnace	●		●	●			●		
	(c) Blower Air					●			●	●
	(d) Control Room Air					●			●	
	(e) Air to Electrical Equipment					●			●	●
	(f) Steam Power Plant			●				●		
5	Sintering Plant		●	●				●		
6	Bessemer Converter	●		●	●			●	●	
7	Open Hearth									
	(a) Raw Materials			●		●				
	(b) Waste Gases				●			●		
8	Electric Furnace				●			●		
9	Power Houses				●	●			●	
10	Scarfing Machines (Blooming Mill)				●		●			
11	Furnaces (Coal Fired)			●				●		
12	Pickling Units				●				●	

Ore, Limestone, and Coal Handling

The receipt of ore at the dock and its subsequent transfer from boats to stockpile or to transfer cars are usually effected on such a scale that there is little that can be done to control dust. The subsequent handling of the ore to the blast furnace high dock and finally to the furnace offers some additional dust emission and collection problems. In plants where the ore is passed through a screening operation prior to its being fed to the blast furnace or sintering plant, the screening plant process and material handling equipment can be protected with hoods, ventilating fans, and recovery equipment, such as cloth filters. Naturally, the dew point is a critical item here.

Limestone handling offers little or no dust problem, since it is generally handled in large sizes with very little fines. Problems will exist at the limestone preparation plant, where cloth filters again offer a reasonable solution.

Coal crushing, blending stations, and belt transfer points are all places to which consideration can be given for suitable hooding, dust removal, and recovery equipment. In such plants the original layout should at least include space for future dust control.

Sintering Plant

The travelling pallet type of sintering equipment is coming into more and more common use, and these units are being equipped with mechanical collectors, either separately or in series with electrical precipitation equipment. Each plant must be considered separately, since the dust and fume problem will depend upon the sintering plant operation, the relative amounts of screened ore fines, limestone fines, returned blast furnace dust, rewatered and filtered fines from primary washers, coke breeze, or coal.

The gas volume to be handled varies from 120 to 160 cfm per ton of sinter per day. The dust loading to the multiclone unit will vary over a wide range from approximately 3 grains to $\frac{1}{4}$ grain per cubic foot or less. The coarser fraction is removed by means of large-diameter cyclones or more efficient small-diameter tubes in multiple units. Dust content to the electrical precipitation unit is in the range of 0·2 to 0·6 grain per cubic foot. Temperature will be in the range of 250 to 400° F.

The recovery efficiency of mechanical collectors is in the range of 80 to 85 per cent, and with the combination of mechanical collectors and precipitators, the overall efficiency will be in the range of 98 to 99 per cent.

Fig. 1 shows an outline drawing of a typical sintering plant operation with multiclone and precipitator for dust collection. Many of these units are used in steam power plants. The draught loss across the mechanical collector and precipitator is $2\frac{1}{2}$ to 3 inches water gauge.

A dusting problem exists at the exit end of the machine, where separation of coarse and fines is made. Multiclone units have here proved satisfactory for dust removal. The large pieces of sinter for the blast furnace or open hearth offer little or no dust problem. However, the fines being returned to the feed bins are dry and

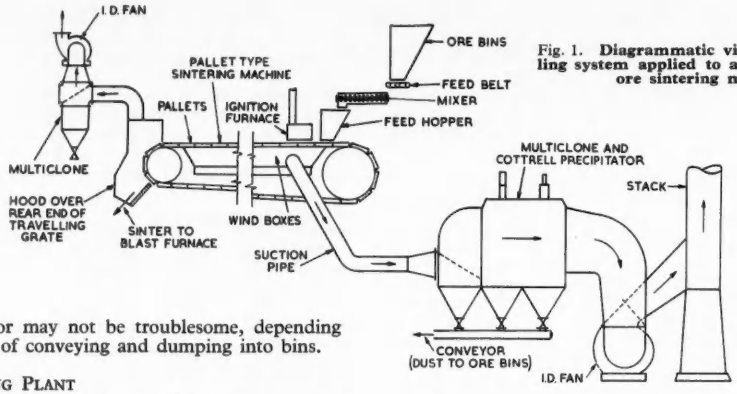


Fig. 1. **Diagrammatic view of dust handling system applied to a pallet-type iron ore sintering machine.**

hot, and may or may not be troublesome, depending on the method of conveying and dumping into bins.

Coke Screening Plant

The charging and discharging of the coke ovens and the subsequent cartage to the quenching station and quenching are all of such a magnitude that any dust or vapour problem is not at present considered of a serious nature. The same is true of the handling of coke on the coke wharf. The coke screening plant, where roughly 70 per cent of the coke is sized for the blast furnace, and where 30 per cent, consisting of the fine fractions, is sent to the power house or disposed of separately, offers a number of sources of dust which can be satisfactorily taken care of through suitable hoods, ventilation, and recovery equipment. However, this is difficult once a plant has gone into operation, and it would be desirable to include, or at least to make provision for, dust recovery equipment at the time of construction of the plant.

Coke Oven Gas Cleaning

Coke oven gas cleaning, by means of electrical precipitators, either in single or two-stage operation, is considered standard practice in the industry and is extensively covered in the literature.

Blast Furnaces

Dust removal from iron blast-furnace gas is perhaps the most familiar ground on which members of the dust cleaning companies meet the steel industry. With furnaces being blown at ever-increasing rates, dust production has augmented enormously. Primary gas washers are handling more gas, and as a result electrical precipitator loads have increased. Where precipitator inlet concentrations used to be of the order of 0·1 to 0·2 grain per cubic foot, these are now reaching 0·3 grain and over. Nevertheless, higher efficiencies are being sought to maintain cleanliness at boilers, stoves, soaking pits, and coke ovens.

New 1400-ton furnaces with air blast in excess of 100,000 cfm are now common. These are being provided with improved scrubbers, to reduce the dust to 0·2 grain or less and are then followed with precipitators to provide concentrations for coke ovens of less than 0·003 grain per cu ft and less than 0·007 for steam power boilers and gas mixing stations.

It has been only recently that any major design changes have occurred in blast furnace gas precipitators. The advent of the centre inlet design, after considerable experiment, has proved to have advantages over former designs. The single centre inlet for dirty gas has provided better distribution to the collecting tubes. Modifications to electrode supports, electrode spacer grating, pond arrangement, and flushing system have reduced or eliminated former problems. More than 25 of these units have been supplied to the steel industry, both in the U.S.A. and elsewhere.

Test data from a recent Australian installation show that dust concentrations as great as 0·265 grain per cu ft at inlet have been cleaned to 0·0031 grain at outlet. Consistent cleaning from 0·2 to 0·3 grain to below 0·004 grain is being obtained.

Extensive work has been done on ferromanganese blast furnaces by the steel industry and this problem has been solved by a special adaptation of electrical precipitation.

Much in the public eye is the desire of the steel industry to reduce open-hearth stack emissions. In Los Angeles County, for instance, regulations permit only a 40-lb/hr discharge from a process handling in excess of 60,000 lb/hr. Open-hearth furnaces of 225-ton charges are in this category.

To date, few open hearths have been equipped with electrical precipitators. In California, four small furnaces, melting scrap, have been successfully equipped. However, this is not what the steel industry considers as standard for open-hearth practice. One 225-ton furnace has recently been equipped in a Western steel plant and a number in a new Eastern plant. These furnaces are standard hot metal and scrap charge for ultimate production of tube and flat rolled material.

The open hearth, with its many stages of scrap charging, hot metal additions, ore, lime, and alloy requirements, is a real problem in electrical precipitation, since from every one of the operating phases a different dust is produced in varying concentrations, with different gas flows and temperatures, and this constantly changing group of variables prevents precise and calculated design. Resistivity of the dust, moisture, and temperature of the gas greatly influence the precipitator operation. The problem is to find one set of design conditions for a specific open-hearth furnace, capable of providing the best overall average results in the precipitator. Each installation usually requires some field adjustment, and so far no operating data are available.

Open-Hearth Raw Materials

The handling of raw materials around an open-hearth plant, such as lime, ore, and ferrous alloys, produces some dust problems, but, again, practical and economical considerations are governing factors.

Power Houses

Steel mill power houses contain a multiplicity of high-power motors, generator sets, and controls requiring cooling air in large quantities. Economic and space considerations bring up many interesting problems of re-circulation, refrigeration, make-up air, dew point, and cloth-type cleaning equipment. Power houses throughout the U.S.A. are noted for their

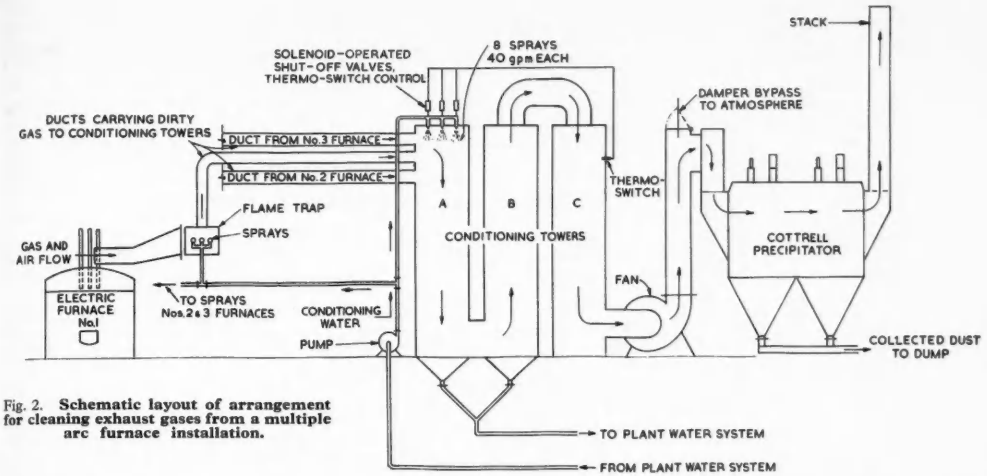


Fig. 2. **Schematic layout of arrangement for cleaning exhaust gases from a multiple arc furnace installation.**

cleanliness and, unless air pollution is retarded, more and better cleaning equipment is indicated.

Bessemer Converters

Bessemer converters offer dust control engineers probably the most challenging problem in the steel industry. The equipment is large and operations are carried out on a considerable scale. In addition, the operation is cyclic and temperature, gas volume, dust, and fumes vary over a wide range.

Average size converters handle charges of 20 to 35 tons with two to three cycles per hour. The gas volume at the converter throat is controlled by the blower, but the temperature may range from ambient to 3000-3500° F.

Solids in the gas stream may be molten, plastic, metallic particles, or oxides condensed from the gases in the form of fume particles. These latter particles are in a sub-micron range.

Suitable hooding provides an engineering problem. If the hooding is close to the converter, high temperature and spittings adherence can be a source of trouble. Since the converter flame may be 40 feet or more in length, hooding at some distance from the converter throat has possibilities, but this reduces the probability of collecting all the dust and fumes and increases the total gas volume which must be handled in the collection equipment. Aside from high-temperature and spittings problems, the movement of the furnace and flame are additional complications.

Test work in the field, by sampling with a simple pipe inserted in the gas stream and cooled by radiation, indicates dust loadings of the order of 0·8 grain per cu ft. Mechanical collector efficiency, using 9-in. tubes, is in the range of 70 per cent. However, data indicate that electrical precipitation can be used satisfactorily and any desired efficiency obtained.

Electric Furnaces

Here, the question of confining gases to as small a volume as possible is again important. In most cases a great deal of ingenuity is required in the design of satisfactory hoods and accessory equipment. In existing plants with little available room the problem is aggravated. For new plants, considerations should be given to providing space for possible future gas cleaning equipment.

Figure 2 shows a diagrammatic arrangement of an existing plant with two 75-ton furnaces and one 50-ton furnace in successful operation. The collecting duct encloses the three electrodes as closely as possible and is a part of the swinging furnace roof. In the closed position, this duct matches up with the entrance to the flame hood, a brick and steel structure mounted beside each furnace, having one horizontal reversal of gas flow. Its design and size were dictated by the space available. Water is sprayed into this hood up to a rate of 25 U.S. gpm and is all evaporated. This serves partially to humidify the gases and to quench the flames. Fan suction provides ample draught, with the exception of the more violent periods of bath reactions when some gases escape collection. The collected gases pass through uninsulated steel ducts to a spray tower, where the inlet temperature range is 300 to 500° F, and loading up to approximately 1 grain per cu ft.

The gases are cooled by direct contact cooling with water sprays at the first tower (A), and the quantity of sprayed water is controlled by the temperature in the third tower (C).

Approximately 25 per cent of the dust is composed of zinc oxide fumes, which are very difficult to collect. Experience shows that each electric furnace problem will need to be investigated before suitable collection equipment can be designed.

For small furnaces, such as those used for making steel castings, it is sometimes possible to dilute the gases to 200° F or less and to use a bag filter.

Where machine turnings, oily scrap, and bundles, containing a number of non-ferrous metals, are charged, it may be necessary to scrub the gases first and then pass them through a steel or wood pipe-type electrical precipitator.

Blooming Mills

There is very little dust formation in blooming mill operation; however, the introduction of scarfing machines introduces a new problem.

The hot, moist, fume- and dust-bearing gases are being handled in an electrical precipitator at one plant. This is not an easy problem, as space limitations in existing plants again make layouts difficult.

Hot Strip Mills

Oxide formation at the exit side of six-stand continuous hot strip mills may or may not cause sufficient nuisance to make consideration of gas-cleaning equipment important. Large volumes containing small concentrations mean large equipment and, once again, hooding and collecting ducts become disproportionately large.

(*Concluded on page* 470)

Flow through Nozzles in Rocket Motors

By R. KLING and R. LEBOEUF. (From *La Recherche Aéronautique*, No. 35, September-October, 1953, pp. 35-41, 12 illustrations.)

IN rocket motors and jet engines, the injection system must be able to deliver combustible materials into the combustion chamber under conditions which will facilitate the breaking up of the jet, and its subsequent atomisation and mixing with oxidising agents. Particularly with rocket motors, the injection system is of primary importance, since in most cases there is no other means of physical action on mixture formation and subsequent combustion, whereas in jet engines a careful arrangement of the air inlets can improve eddy effects and mixing.

As the first part of a general investigation into mixture formation in combustion chambers, a study was made of flow through nozzle orifices, under conditions as similar as possible to those actually occurring in practice. The flow characteristics were determined mainly by measuring the discharge coefficients of various orifices. The parameters considered include nozzle geometry, injection pressure, liquid temperature, chamber pressure, and type of liquid injected. Although the tests were carried out to obtain basic data for rocket motor applications, some of the results are also useful for jet engines.

INJECTION OF LIQUID FUELS IN ROCKET MOTORS

The systems considered are those in which the liquid fuel is injected under a pressure which is kept fairly constant by a control device. For a liquid of mass-density ρ, the volumetric rate of flow Q per unit time, through an orifice of sectional area A, under a pressure head Δp, is then given by

$$Q = \alpha A \sqrt{2 \Delta p / \rho}$$

where α is the discharge coefficient. From this relation, it is seen that, if the value of Δp is maintained constant, the rate of flow will vary as a function of the discharge coefficient α. Consequently, no gear pumps or plunger systems are considered here, as with these any variation of α causes a change in Δp and hence alters the quality of the injection (i.e., the penetration and atomisation).

Rocket motors are characterised by high discharge rates of liquid substances and particular difficulties in the preparation of the combustible mixture, because the oxidant, as well as the fuel, is in a liquid state. The injection pressures used are not very high, being generally below 145 psi.

In practice, the injection systems used can be subdivided into three main types, according to whether the atomisation of the liquids is mainly due to (a) chamber back-pressure and turbulence, (b) jet impacts on walls, or (c) the impact of two jets acting upon each other.

In the first case, the orifices are generally cylindrical and produce parallel jets of liquid. The mixture occurs mainly by turbulent diffusion and the structure of the mist obtained thus depends directly on the conditions prevailing in the combustion chamber. Generally, the specific fuel consumption of these systems is rather poor.

Systems with atomisation by jet impact on walls (Fig. 1) have been employed to a rather limited extent only. The Walter 109-509 motor produced in Germany was of this type, and used the catalytic decomposition of hydrogen peroxide. The system apparently gives low fuel consumptions with fairly uniform combustion at relatively low injection pressures. Its main drawback is a high, localised heat flux produced at certain positions in the injection head.

The injection system with two-jet impact (Fig. 2) is at present the most widely used. The mutual impact of the jets is favourable for the breaking-up and mixing of the two liquids and can be employed in a variety of combustion chamber designs. It also permits various combinations of jets to be obtained, as, for instance, separate jet impacts of the oxidant and the fuel, with subsequent mixture of the two sprays, or oblique impact of two jets of oxidising agent, with the fuel issuing in a third jet directed at the point of impact of the first two jets.

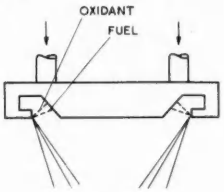


Fig. 1.

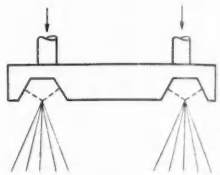


Fig. 2.

These injection systems reach fairly low values for fuel consumption, but sometimes they also give rise to high-frequency pressure pulses in the chamber. The causes of these fluctuations are clarified to some extent by the results of the measurements carried out. Slot-type orifices, which produce sheet-like sprays, are not considered. Although sprays of this type break up more easily than jets, these systems are not frequently used at present.

In all these devices, the precision of manufacture of the orifice is an important factor. Some authors[1] have stated that high-quality production is an essential condition for the satisfactory operation of a rocket motor. This is confirmed, to a certain extent, by the authors' test results.

METHOD OF MEASUREMENT AND TEST EQUIPMENT

The discharge coefficients of the orifices under investigation were determined by means of the relation $Q = \alpha A \sqrt{2 \Delta p / \rho}$. For this purpose, it is sufficient to measure the volumetric rate of flow Q, the geometrical sectional area A of the orifice, and the injection pressure Δp, using for the mass-density ρ of the liquid its value at atmospheric pressure. This value can be regarded as constant over the range of pressures considered.

The rate of flow Q was determined by means of a flowmeter based on the following principle :—

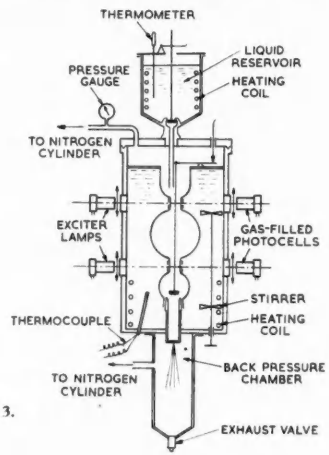


Fig. 3.

The liquid used for the measurements is contained in a Pyrex test tube, with a spherical central portion limited by two constrictions, so as to determine a volume V of the order of 200 cc (Fig. 3). This test tube is fixed within a thick-walled metal container designed as a thermostatic tank and capable of withstanding pressures up to about 700 psi.

This container is normally filled with water and provided with an externally driven stirrer. The lower end of the test tube has an enlarged section and can be opened or closed by a valve with a linkage system which is also externally operated.

The orifice to be investigated is pierced in a small stainless steel disc of 7 mm diameter, which is screwed to a metal adaptor at the lower end of the test tube.

The pressure head required for the injection of the liquid is obtained from a cylinder of about 40 litres capacity, filled with gas (nitrogen) at the specified pressure. Under these conditions, the pressure variations due to the increase in volume during discharge do not exceed 0·5 per cent. This increase is taken into account by a suitable correction in the evaluation of the measurements. Thus, the rate of flow through the orifice is determined after obtaining steady flow conditions, for a volume V of the liquid, which is known from preliminary tests.

The duration of the flow is measured by means of two gas-filled photoelectric cells. Each of these receives a narrow beam of light passing through the body of the apparatus, from windows provided with adjustable sighting arrangements at the constricted portions of the test tube. During the flow of the liquid, the meniscus limiting the free surface passes through the light beams and causes pulses to be generated in the photocell circuits. These pulses are used for the triggering and subsequent stopping of an electronic chronoscope with indications in hundredths of a second.

In order to operate under fully defined conditions, the injection orifices were made with particular care. After piercing, a calibrated sphere was, as a rule, forced through the orifice, so as to obtain a smooth inside surface and an aperture of accurate diameter.

For a study of the effect of the temperature of the liquid injected, separate heating devices were provided for the body of the apparatus and the reservoir of liquid situated above it. The influence of back-pressure at the outlet was investigated by means of a small chamber filled with gas under pressure, into which the liquid was injected. This chamber was also connected to a bottle of 40 litres capacity, so as to reduce back-pressure fluctuations during measurement.

During the tests with discharge into the atmosphere, photographs of the free jet were taken by means of electric sparks. With these photographs, it was possible to correlate to some extent the appearance of the jet to the flow conditions in the orifice. The liquid employed was distilled water in all except one series of tests, where alcohol was used. The injection pressure was varied from about 28 to 170 psi, and the temperature from 20 to 80° C. In subsequent tests, the back pressure was varied from about 145 to 430 psi.

Details and Analysis of Test Results

Effects of injection pressure and orifice shape:—The tests were initiated with cylindrical orifices, rounded at the inlet, which give high discharge coefficients and minimum turbulence. The orifices tested had diameters of 0·5, 0·8, 1·0 and 1·2 mm, a length/diameter ratio of 3 : 1, and a radius of curvature at inlet equal to the diameter.

For each of the first two diameters, ten apparently identical orifices were investigated. The jets were discharged into the atmosphere at ambient temperature and the discharge coefficients of the orifices were plotted against injection pressure.

The results obtained with increasing injection pressure (Fig. 4) in each case show first a slight increase of the discharge coefficient, followed by a step-like drop. The critical pressure at which this drop occurs varies for each of the orifices tested, this being particularly important as it occurs at low pressures. After this sudden variation, the discharge coefficient continues to decline, but at a much slower rate.

The jet first appears as a clear cylindrical discharge at low injection pressures; when the pressure is increased, the jet has a dull lustre and slight ripples appear before the sudden drop of the discharge coefficient. Thereafter, the jet is clear again and has a divergent-convergent cross-section which broadens out as the pressure is increased. Similar changes have been observed with orifices of different diameters.

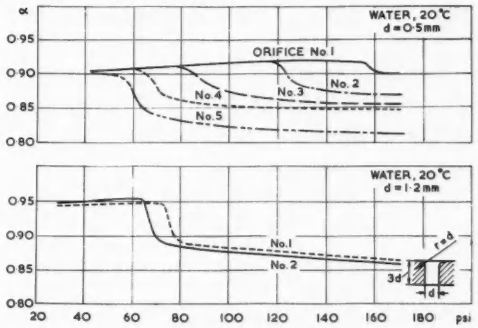


Fig. 4.

For a further correlation of the above results, tests were also carried out with sharp-edge (non-radiused) orifices as well as with orifices in thin plate. For orifices with a sharp inlet edge, the sudden drop of the discharge coefficient (from $\alpha = 0{\cdot}78$ to $\alpha = 0{\cdot}62$) occurs at low injection pressures (28 to 40 psi). The lower value obtained for α is usually associated with reversed flow in conical orifices. In testing orifices of the latter type, with a diameter ratio $D/d = 2$ and a length/diameter ratio $L/d = 5$, the smaller diameter d being 2 mm, it was found that α remains at 0·94-0·95 for convergent flow and has a value of 0·62-0·60 for flow in the divergent direction.

The jet from sharp-edge orifices is perfectly cylindrical and generally shows no signs of breaking-up before reaching a considerable distance from the orifice. Its penetration is therefore considerable.

The importance of the breaking away of the flow in these phenomena was shown by Northup[2] using transparent orifices. In an orifice with a non-radiused inlet, the flow contracts at the upstream corners and broadens out afterwards, so as to fill the entire section at the outlet. This results in a fairly high discharge coefficient. However, beyond a certain value of injection pressure, the jet tends to jump free from the wall and this results in a drop of the discharge coefficient to values similar to those obtained for thin plate orifices.

In view of the results shown in Fig. 4, it may be said that this breaking away of the flow tends to occur not only in sharp-edge orifices but also, under certain conditions, in rounded-inlet type orifices. In the latter, the pressure at which this phenomenon occurs depends on the shape of the curved inlet section, and the different critical pressure values observed for apparently identical orifices are due merely to inevitable small differences in the manufacture of these components. Moreover, for certain orifices no notable decrease of the discharge coefficient was observed, in the range of pressures considered, owing, no doubt, to a particularly good profile at the inlet section.

It is usual to regard the discharge coefficient α as the product of a contraction coefficient $\mu = a/A$ multiplied by another coefficient φ, which is a function of

friction and turbulence losses. According to the case considered, either of these coefficients may be the important factor for α:—(i) For an orifice in thin plate, φ is affected only by the inlet eddies, and the variations of α seem to depend mainly on the contraction coefficient μ, which varies with velocity. (ii) For cylindrical orifices, the coefficient φ seems to have a preponderant effect. This appears to be confirmed by a series of measurements which were made on an orifice of 0·8 mm diameter, which was gradually reduced in length from 10 d to 2 d.

The rounded-inlet section of this orifice had a radius r equal to the diameter. The curves obtained for the discharge coefficient α with different L/d-values, plotted against injection pressure, show a slight rise up to $\Delta p = 57$ psi, approximately, and are fairly flat thereafter. The values of α in the range above 57 psi for various L/d ratios (given in brackets) are as follows :— $\alpha = 0{\cdot}89$ (10), 0·895 (8), 0·905 (6), 0·925 (4), and 0·94 (3). The slight increase in α with injection pressures, that is, with increasing Reynolds numbers, before tending towards a limiting value, has also been observed with various cylindrical orifices before breaking away of the flow occurs.

For the orifices tested, the Reynolds numbers were generally between 15,000 and 42,000, so that the flow after the contracted section is always turbulent for lengths L of the order of several diameters. Thus, it may be assumed that turbulent flow conditions prevail over a fairly important fraction of the total length.

For circular passages, the factor φ can then be related to a pressure-loss coefficient λ, for which the variations are given by Nikuradse's curves. The region in which α, plotted against pressures, tends to be independent of the Reynolds number would then correspond to the region in Nikuradse's curves, where λ tends towards a constant value depending only on wall roughness. To improve the stability of operating conditions in combustion chambers, it may thus be an advantage in some cases to use orifices for which the discharge coefficient is independent of Reynolds numbers, thus reducing effects due to the viscosity of the fuel injected. This result can be achieved with low Reynolds numbers corresponding to increased surface roughness and has in fact been employed in injectors developed by Esnault-Pelterie[3]. Naturally, the discharge coefficients obtained are comparatively low.

Generally, however, it is useful to have orifices with high discharge coefficients, in order to reduce to a minimum the number required for a given flow rate. As rounded convergent sections are difficult to produce in practice, in view of the small diameters involved, the tendency has been to employ conical sections, which, in spite of the straight taper, give approximately equivalent results. As already mentioned, discharge coefficients of about 0·95 can be obtained with conical sections, using L/d ratios of 5 : 1. In the tests previously described, the total aperture angles chosen for these inlets were 11° 20′ or 22° 40′, but the angle values are rather arbitrary.

Satisfactory results are achieved with nozzles consisting of a short initial section with conical taper, followed by a straight section about twice as long as the tapered portion (Fig. 5). Two orifices tested both gave discharge coefficients of about 0·92, and showed no sudden drop over the entire range of injection pressures generally used (28 to 170 psi).

Effect of temperature of the liquid injected:—This effect was investigated for temperatures ranging from 20 to 80° C. As expected, the influence of temperature is particularly noticeable with orifices in which the breaking away of the flow occurs within the normal range of injection pressures (Fig. 6). Before the sudden drop, the discharge coefficient is improved slightly, owing to the reduced viscosity obtained with inceased temperature. However, the critical pressure then appears at a much lower value than at room temperature.

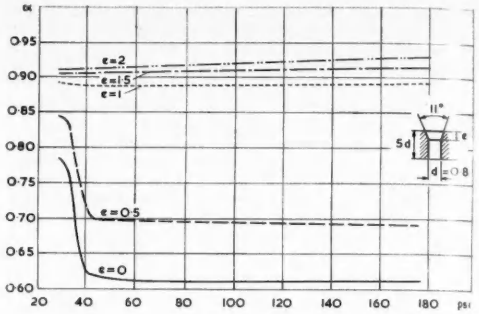


Fig. 5.

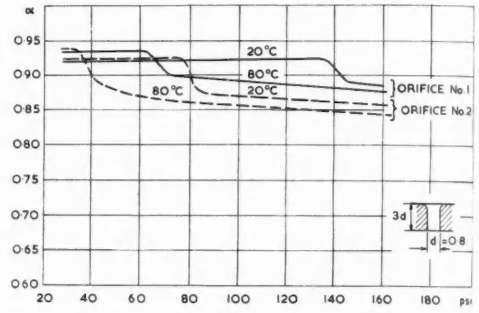


Fig. 6.

In one case, the critical conditions occurred at 63 psi at 80° C, instead of at 125 psi at 20° C. In another test, using a sharp-edge cylindrical orifice, the drop was observed at 29 psi.

It appears that these variations should be attributed mainly to the rise in vapour pressure of the liquid, which favours the development of the cavity occurring in the contracted area of the jet.

Effect of back-pressure:—It was to be expected that sufficiently high values of back pressure would prevent the occurrence of cavitation processes which take place in the breaking away of the liquid, and thus affect the discharge coefficient. This was confirmed by experiments. Particularly marked differences were obtained with a sharp-edge orifice of 0·8 mm diameter, for which the drop in α occurred at a pressure of only 28·4 psi when discharging into the atmosphere. With a back pressure of 430 psi, the drop was completely eliminated, and the discharge coefficient remained constant for liquid temperatures varying from ambient temperature to 80° C.

With sharp-edge orifices of 0·8 mm diameter and an L/d ratio of 5 : 1, operating with a pressure head of 160 psi, the discharge coefficient was about 0·61 at 56 psi back pressure, and increased steeply thereafter to 0·785-0·80 for back pressures of 70 to 85 psi, remaining fairly constant at still higher pressures. Similar results were obtained for liquid temperatures of 20 and 80° C. A similar orifice, but with an L/d ratio reduced to 2 : 1, showed an only slightly smaller rise of α, up to 0·77, so that the influence of the L/d ratio would appear to be comparatively small.

Effect of the type of liquid:—All the tests previously described were carried out with distilled water. It appeared necessary, therefore, to carry out further tests with a more volatile liquid, and ethanol was chosen for this purpose, since it is used as a fuel in certain types of rockets.

There is little change with ethanol as regards the

critical values of back pressure :—At a liquid temperature of 20° C, the discharge coefficient rises from 0·62 to about 0·75, when the back pressure is varied from 70 to 110-125 psi, for sharp-edge orifices of 0·8 mm diameter with an L/d ratio of unity. At 75° C, the rise in α is also from 0·62 to about 0·75, but occurs for back pressures from 140 to 200-230 psi. However, with this volatile liquid, unstable conditions appear at higher pressures, which result in extensive scatter (10 to 25 per cent) in the results of successive tests. The scatter increases when the temperature of the liquid injected is increased, but is reduced by using higher back pressures. At 75° C, with a differential pressure of 160 psi and a back pressure in the neighbourhood of 200 psi, the 25 per cent scatter in the α-values could lead to dangerously unstable conditions in the combustion chamber.

BIBLIOGRAPHY

(1) K. STERLING : Jets from injection nozzles and hydraulic factors in the study of rocket motors. *J. Amer. Rocket Soc.*, Nos. 22/23, May-June, 1952, pp. 132-138.

(2) NORTHUP : Flow stability in small orifices. General Electric Co. "Hermes" project. *J. A.R.S.*, Nos. 49/51, 1951.

(3) J. J. BARRE : Injection and regulation in self-propelled missiles with liquid fuels. *Mém. Artill. Franc.*, No. 22/2, 1948, pp. 332-376.

RUSSIA

The Design of Equivalent Circuits for Electromagnetic Apparatus

By A. S. ROSENKRANTZ. (From *Elektritchevstvo*, No. 5, 1953, pp. 67-74, 7 illustrations.)

Model testing techniques as design aids are gaining favour everywhere. In the design of electrical apparatus models are particularly useful when the original can be represented by an equivalent circuit containing only concentrated circuit elements without conditions on their positioning in space. In the following an explanation is given of the principles which govern the synthesis of such equivalent circuits representing electrical a.c. apparatus containing magnetic as well as electrical circuits.

Two geometric, or more precisely, topological conceptions, inseparable from the equations of electric and magnetic circuits, are the following:—(1) The closed path underlying the equations which express Kirchoff's second law. (2) The aggregate of all branches connecting two parts of the circuit situated on the two sides of a closed surface. In other words, the group of all those branches which must be cut to divide the complete circuit into two disconnected parts.

Such a group of branches, to which Kirchoff's first law is applied, is conveniently called the connecting aggregate. Examples of reversible configuration are shown in Fig. 1a, by the branches, 1, 2, 3, or 1, 2, 4 and in Fig. 1b, by 3, 1, 10, 9, 8, 11, or 3, 2, 9, 5, 6. The junction is a particular case of such an aggregate, i.e., several branches connected at a single point. An example of irreversible configuration is shown in Fig. 2.

Reciprocal circuits are those in which closed paths and connecting aggregates are correspondingly interchanged. Any closed path of one circuit corresponds to a connecting aggregate of the reciprocal circuit. Circuits for which reciprocal circuits exist are called reversible. In the terminology of topology such systems are known as plane systems, because they can be represented in a plane without intersections.

Every electromagnetic apparatus consists of a more or less complicated magnetic circuit, some branches of which are surrounded by windings connected in an electrical circuit. Starting initially with linear circuits and sinusoidally varying magnitudes, the equations of the magnetic circuit can be set up in a symmetrical form, if the e.m.f.'s and the m.m.f.'s are respectively considered to be negative voltage drops and magnetic pressure drops of equal magnitude.

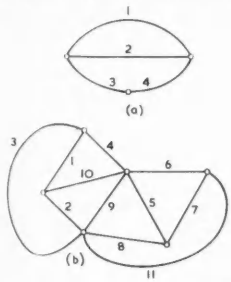


Fig. 1. **Examples of reversible configuration.**

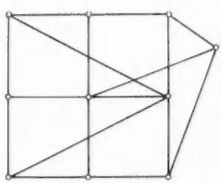


Fig. 2. **Example of irreversible configuration.**

Here, the replacement scheme for the electromagnetic apparatus consists of two electrical circuits, one of which is a substitute for the electrical part of the apparatus and the other for the magnetic part. The simultaneous model representation of both parts demands first of all the introduction of four-poles connecting the two electrical circuits in the same way that an elementary electro-magnetic four-pole (surrounded by a dotted line in Fig. 3) connects the electrical and magnetic circuits in the electromagnetic apparatus Generally, in a practical installation, there is no electrical connection between the electrical and magnetic circuit, and therefore in the equivalent purely electrical circuit such a connection must also be absent. For this reason the most suitable purely electrical four-pole, equivalent to the elementary electromagnetic four-pole, is the coreless transformer.

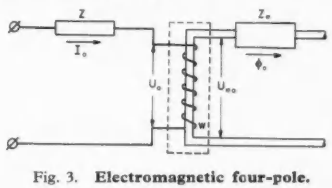


Fig. 3. **Electromagnetic four-pole.**

The electro-magnetic four-pole (Fig. 3) is governed by the following two equations:

$$U_0 = w\, j\, \omega\, \phi_0 \quad .. \quad .. \quad (1)$$

$$U_{m0} = -\, w\, I_0 \quad .. \quad .. \quad (2)$$

The ideal equivalent transformer (Fig. 4) is governed by two similar equations:

$$U_{\mathrm{I}} = n\, U_{\mathrm{II}} \quad .. \quad .. \quad .. \quad (3)$$

$$I_{\mathrm{II}} = -\, n\, I_{\mathrm{I}} \quad .. \quad .. \quad .. \quad (4)$$

The notation for these equations is indicated in Figs. 3 and 4.

Either of two types of equivalence can be selected. On the one hand, the voltage U_{I} and the current I_{I} of the model can represent the voltage U_0 and the current I_0 of the original apparatus. If so, the voltage U_{II} represents the magnitude $j\,\omega\,\phi_0$ and the current I_{II}

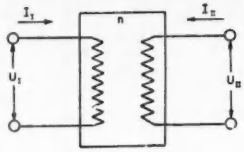


Fig. 4. **Notation for transformer.**

represents the magnetic pressure U_{mo}. A model so designed will, in its electrical part, be the image of the original (in other words, the model circuit will differ from the original circuit only in scale). This system of model representation can be called the "direct equivalent system."

On the other hand, the model may be so set up that its electric current represents the magnetic flux of the original and the magnetic pressure of the original is replaced by an electrical voltage in the model. If so, a circuit is obtained whose electrical characteristics are reciprocal to those of the original apparatus. This system of model representation can be called the "inverse equivalent system."

An examination of the relations between model and original reveals that when a direct equivalent system is used, the magnetic circuit of the original is represented in the model by an electrical circuit of reciprocal configuration.

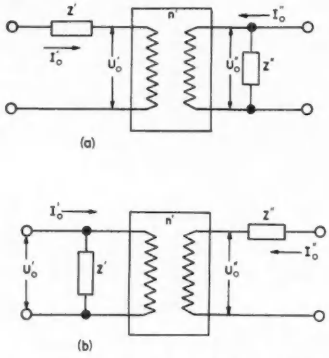
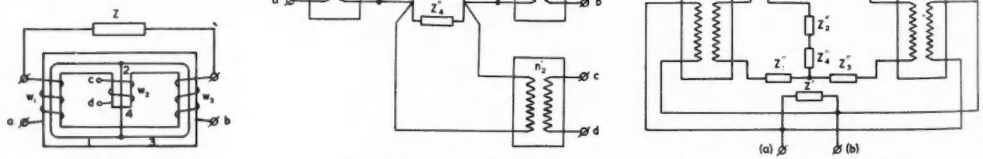


Fig. 5. **Direct (a) and inverse (b) equivalent circuits of electromagnetic four-poles.**

When, however, an inverse equivalent system is used, then the configuration of the magnetic circuit of the original and its equivalent electrical circuit in the model are identical, but the electrical part of the original is represented in the model by an electrical circuit of reciprocal configuration. These conclusions are illustrated in Fig. 5, where the direct and inverse equivalent circuits, representing the elementary electromagnetic four-pole of Fig. 3, are shown.

Fig. 6 shows diagramatically an example of an original electromagnetic apparatus (a) and its two purely electrical models, of which (b) uses the direct equivalent system and (c) the inverse equivalent system.



(a) Original apparatus. (b) Direct equivalent circuit. (c) Inverse equivalent circuit.

Fig. 6. **Example of equivalent circuits.**

To ensure that model representation can be embodied in practice, it is necessary to fulfill two conditions, *viz.*: (1) Circuits of the required configuration must be possible. (2) Circuit elements, in agreement with the required relations between model and original quantities, must be practicable.

For the direct equivalent system the first condition reduces to the condition of reversibility of the magnetic circuit, since the electrical part of the apparatus is represented in the model by a circuit of identical configuration. In practice, irreversible magnetic circuits are extremely rare. The second condition is also easily fulfilled for the direct equivalent system. The complex magnetic resistance has an imaginary part associated, as is well known, with power losses due to hysteresis and eddy currents. Both the real and imaginary parts of the complex magnetic resistance are always positive, insofar as, in the presence of losses, the magnetic resistance leads the magnetic flux by a phase angle below 90 deg.

Such a magnetic resistance is represented in the direct equivalent circuit by an inductive electrical resistance and can always be embodied in a practical resistance element. The electrical circuit of the electromagnetic apparatus is represented by a similar circuit having elements which differ only in scale from the original.

When an inverse equivalent circuit is used to represent the electromagnetic apparatus, the representation of the electrical part of the apparatus is possible only on condition that this part is reversible. This condition is obviously fulfilled in the majority of practical cases. However, capacities in the original must be represented by negative active resistances. For this reason, in the presence of capacities in the electrical circuit of the original, its inverse equivalent circuit cannot be composed of the ordinary positive resistance elements. On the other hand, the magnetic circuit of the original can always be represented easily in the model.

In certain cases the equivalent circuit of the apparatus must represent the model in a whole range of frequencies, and thus the quantitative relations between the original and the model must be observed at different frequencies. This condition is always fulfilled by that part of the direct equivalent circuit which represents the electrical part of the apparatus. In representing the magnetic part of the apparatus, a difficulty arises in taking account of hysteresis losses, whilst the eddy current loss can be represented by ohmic resistance in a direct equivalent circuit and a constant inductance in an inverse equivalent circuit. Consideration of hysteresis leads to non-linear magnetic circuits.

A complete model representation of a non-linear apparatus requires the reproduction in the equivalent circuit of all those shapes of the curves which relate the instantaneous values of currents, voltages, and magnetic fluxes in each branch of the circuit and in each state of operation.

Equations (1) and (2) applied to the instantaneous values assume the form:

$$u_n = w\, d\varphi/dt \quad .. \quad .. \quad (5)$$

$$u_{mo} = -wi_n \quad .. \quad .. \quad .. \quad (6)$$

These can be transformed into equations giving the instantaneous values of the voltage and current in that transformer winding which forms part of the model circuit representing the magnetic circuit of the original:

$$u'' = m_\phi\, d\varphi/dt \quad .. \quad .. \quad (7)$$

$$i'' = m_{Um}\, u_m \quad .. \quad .. \quad (8)$$

where m_ϕ and m_{Um} are the scale factors of the model determined from the following equations:

$$m_\phi = \frac{m_Z\, m_I}{m_w} \quad .. \quad .. \quad (9)$$

$$m_{Um} = m_w\, m_I \quad .. \quad .. \quad (10)$$

The separate scale factors are defined as follows:

$$Z' = m_Z\, Z \quad .. \quad .. \quad .. \quad (11)$$

$$I' = m_I\, I \quad .. \quad .. \quad .. \quad (12)$$

$$U' = m_U\, U \quad .. \quad .. \quad .. \quad (13)$$

$$m_U = m_Z\, m_I \quad .. \quad .. \quad .. \quad (14)$$

A branch of the electrical circuit representing a magnetic branch of the original obeys the following relation:

$$u'' = \frac{m_\phi}{m_{Um}} \frac{d\varphi}{du_m} \frac{di''}{dt} \quad .. \quad .. \quad (15)$$

This expression shows that such a branch of the model circuit must contain an inductance expressed by the differential equation:

$$L'' = \frac{m_\phi}{m_{Um}} \frac{d\varphi}{du_m} \quad .. \quad .. \quad (16)$$

If the original is non-linear, this inductance must also be non-linear, and it is easy to show that the magnetic curves of the two inductive coils must be similar.

Denoting by B the magnetic induction in the cross-section S of the magnetic conductor, and by H and l the magnetic field intensity and mean length respectively of the magnetic circuit, the following relations between the magnetic characteristic of the magnetic circuit of the original apparatus and the iron core of the inductive coil in the equivalent circuit are obtained:—

$$\frac{dB''}{dH''} = \frac{m_\phi}{m_{Um}} \frac{1}{(w'')^2} \frac{S}{l} \frac{l''}{S''} \frac{dB}{dH} \quad .. \quad (17)$$

$$H'' = \frac{i''\, w''}{l''} = m_{Um}\, w'' \frac{l}{l''} H \quad .. \quad (18)$$

It follows that $H = H''$, and $B = B''$. Hence, the most appropriate core material for the model is the same material as that from which the magnetic circuit of the original is made. If so, the following equations are obtained:

$$m_{Um}\, w'' = l''/l \quad .. \quad .. \quad (19)$$

$$m_\phi = s''\, w''/s \quad .. \quad .. \quad (20)$$

An experimental investigation of the all-electric model circuit, especially with the use of a network analyser, is infinitely more convenient than that of a physically reduced model of the electromagnetic apparatus. This is particularly true when it is desired to examine changes in the design of the magnetic circuit, merely entailing modifications of circuit elements in the equivalent circuit, without involving any mechanical interconnection.

In the first approximation such model investigations are simplified even further by the fact that the magnetisation curves of different ferrous alloys are almost identical when plotted in units representing percentages of certain material constants.

In the direct equivalent system the substitute elements for non-linear circuit elements of the electrical circuit of the original are identical in nature and differ from the original only in scale.

U. S. A.

The Use of Water in Molten Salt Quenching Baths

By E. N. Case and A. M. White. (From *Metal Progress*, Vol. 64, No. 4, October, 1953, pp. 122-124, 2 illustrations.)

Some years ago, the problem of obtaining a molten quenching and tempering bath capable of operating satisfactorily at 275° F or lower was presented to the laboratory of the American Cyanamide Co. The only low-temperature salt in common commercial use is a ternary mixture of sodium nitrate, potassium nitrate, and sodium nitrite, whose freezing point is variously stated at 285 to 290° F. Examination of the literature disclosed several possibilities in other nitrate-nitrite systems, such as those involving sodium, calcium, and lithium nitrates, or in certain chloride systems, but for one reason or another, including extremely hygroscopic nature or high cost, these were abandoned.

It was finally decided to study the addition of a fourth component to the old system consisting of sodium nitrate, potassium nitrate and sodium nitrite. A number of inorganic compounds was investigated, but those which had any beneficial effect presented rather serious disadvantages for commercial operations. Water was ultimately investigated as an additive and the resulting quaternary system was found to have considerable practical usefulness.

In the experimental work, freezing and boiling points were determined on melts of approximately 800 grams in Pyrex glass beakers. The mixtures were melted over a bunsen burner and the temperature of the melt measured by an iron-constantan thermocouple standardised at the temperature of boiling water. A pencil-type unit, in which the iron portion of the thermocouple is also the protection tube, was employed because of its small size and rapid temperature response. An instrument with a range of 0 to 300° C (32 to 572° F) recorded the temperatures.

Operating Ranges

The freezing point was indicated on each cooling curve by a rather abrupt change in its slope and a constant or nearly constant temperature region. Boiling points were determined visually. Frequent weighings were made to establish the actual amount of water in the mixture on which the observations were made, and to replace any losses at the boiling temperature. The data obtained are shown in Fig. 1.

It may be noted that the spread between the freezing point and boiling point is greatest for low concentrations of water, but decreases to a minimum of about 110° F, when the concentration of water is about 7 per cent. Thus, it is apparent that water can be added to the nitrate-nitrite ternary mixture to make a quaternary system of lower freezing point, yet with a

high enough boiling point to provide a useful operating range. It was found that the freezing point of the ternary mixture of salt was 291° F (before water was added), whereas the freezing point in standard text on tool steel reports it to be 285° F. The salt used originally contained 0·14 per cent of moisture and the lower freezing point noted in the literature would result from a higher water content, but one which is still below the maximum limit of 1 per cent allowed by commercial specifications for similar mixtures. Because of the hygroscopic nature of the individual salts, particularly the sodium nitrite, water is readily absorbed by the crystalline salts under normal conditions. The value of 294° F shown in the curve is obtained by extrapolation to zero per cent moisture, and appears to be in substantial agreement with the data of other investigators using dry salts.

Benefits of the salt system containing water can be applied to several practical operations. The most obvious is a tempering bath for temperatures below 300° F. It has been found in actual practice that, once the bath has been prepared with the proper amount of water, it maintains its original composition for long periods at temperatures below the boiling point of the mixture. In the tempering operation, the steel which enters the bath is ordinarily cooler than the bath. Thus, there is no chance of localised boiling driving off any of the water, and the composition remains constant.

Quenching Power

A second and perhaps even more useful application is for martempering or other hot quenching operations. It has already been shown by one investigator that the cooling rates in salt baths at 350° F are comparable with or even higher than those obtained under optimum conditions in oil quenching. If the temperature of the salt bath is lowered (by the addition of water), or even if a water-containing bath is used at an equal temperature, then considerably faster rates are obtained than with oil, and it has been suggested by another investigator that the greater quenching power of a salt bath caused by moisture might be used to harden parts which do not have sufficient hardenability to harden otherwise.

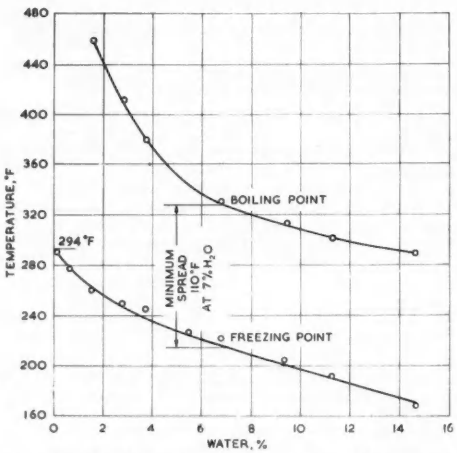


Fig. 1. **Effect of water on the freezing and boiling points of a ternary mixture of potassium nitrate, sodium nitrate, and sodium nitrite.**

The quenching power of the salt may be altered to provide the required degree of hardening for a specific type and size of steel by controlling the amount of water in it. This applies the principles of hardenability, but in this instance the variations considered are in the composition of the quenching medium rather than in the alloy content of the steel. In actual practice, parts of too low hardenability have been salvaged in this manner.

It will be noted in Fig. 1 that the boiling point decreases rather rapidly as the amount of water is increased. While this is not of great consequence if the bath is to be used for tempering, it is a factor which should be taken into consideration when the bath is used for quenching. If hot metal is quenched into a molten salt mixture containing water, the boiling point of the mixture will be exceeded momentarily where it comes in contact with the hot metal. If the mixture is already close to its boiling point, this tendency to boiling and rather rapid vaporisation is increased. The effect is similar, though to a lesser degree, to that observed when hot steel is quenched into warm or hot water. While rapid agitation will serve to decrease the amount of vaporisation, it is a good practice to quench into a mixture which is near its freezing point rather than close to its boiling point.

Maintenance of Composition

The fact that the water evaporates at high temperatures can be put to good use, inasmuch as a bath which has absorbed water can be restored to its correct condition by raising its temperature to, or close to, the boiling point. In order to determine the amount of water present at any time, all that is necessary is to measure the freezing point (or boiling point) of the bath and refer to the graph (Fig. 1). It is not necessary to use the entire melt for this measurement, as a small sample may be dipped out of the pot and the freezing point determined by a thermometer. More water may then be added, if required. If there is already too much, the excess may be evaporated or more of the water-free salt mixture added. In commercial quenching practice, water may be added from time to time, as necessary, to maintain the required quenching power of the bath; no other measure of the amount of water is required.

Some caution must be exercised when water is added, owing to the danger of localised boiling and violent spattering when water is introduced into a molten salt bath at high temperatures. Additions to the nitrate-nitrite bath should be made below 350° F, slowly, while the bath is being well stirred. Even at 350° F, some spattering will occur, but the intensity of the reaction increases greatly with temperature.

The importance of caution cannot be stressed too greatly. The necessity to make water additions at *low* temperature makes it undesirable to apply the technique to molten mixtures which contain nitrates only and which, therefore, have significantly higher melting points. Indications are, however, that the effect on such higher melting mixtures is only slight.

In this connection, it should be mentioned that low-temperature tempering salt on the *cool* side can safely absorb considerable amounts of water; also, such commercial salts, supposedly in dry condition, are prone to absorb moisture from the atmosphere, and may contain up to 1 per cent water without contravening the usual commercial specifications for salt for tempering purposes.

The advantages of this quaternary system may be summed up as follows:—

(1) Molten baths which may be operated at temperatures considerably below 300° F are obtained simply and conveniently by adding water to a mixture of potassium nitrate, sodium nitrite and sodium nitrate, though caution must be exercised when preparing such baths.

(2) The mixture is useful for low-temperature tempering and as a quenching bath of high quenching power, and virtually no additional expense is entailed.

(3) The normal characteristics of the bath can be restored when desired.

The Ferraris Motor and its Application in Control Systems

By H. UMLAUFT. (From *Feinwerktechnik*, Vol. 57, No. 8, August, 1953, pp. 229-235, 19 illustrations.)

It is not generally known that it is possible to build motors of the Ferraris type with light-alloy rotors capable of developing shaft powers of several hundred watts, such motors being particularly suitable as drive motors for control systems.

POWER drives for continuous electrically-operated control units must permit easy and rapid reversal of motion to be obtained. Additional requirements are a high starting torque to overcome initial friction and the ability to operate with full inertia torque right up to the end positions of the positioning device, without producing unduly high loads on other components of the drive to which they are coupled. Moreover, such motors should be able to remain at standstill positions with all electrical connections left on, without suffering damage from overheating.

CONSTRUCTION AND CIRCUIT CONNECTIONS OF THE FERRARIS MOTOR

The main design features of the Ferraris motor are shown in Fig. 1. The stator consists of packets of slotted laminations (1) carrying the stator windings (2). The magnetic circuit is completed by a stationary laminated iron core (4) fitted inside the stator. The rotor (3), situated in the air-gap between these components, is a thin-walled aluminium drum with a small moment of inertia. To give an idea of size, a fully-enclosed Ferraris motor of 30 watts continuous power rating at 1500 rpm is somewhat smaller than a d.c. motor of 50 watts nominal power of the open type, which can give only 30 watts when operating as an enclosed unit, owing to overheating considerations.

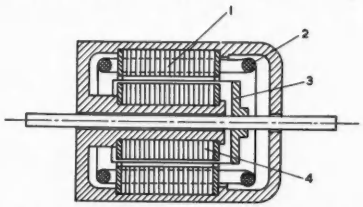


Fig. 1. **Principal design features of the Ferraris motor.**

Generally, control motors are required only for small and medium power outputs and, as most control problems are worked out without resorting to three-phase currents, these motors are nearly always designed for operation from a single-phase a.c. mains. The Ferraris motor employs a two-phase stationary winding, with one phase connected to the mains and the other to the circuit of the control current (Fig. 2), which determines the direction of rotation and the motor torque.

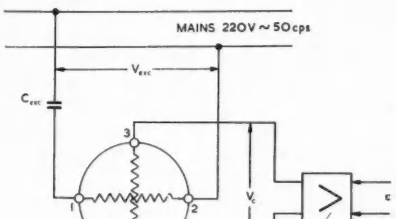


Fig. 2. **Ferraris motor with separate control and excitation windings, used as a positioning motor in a control circuit.** (*a*) Ferraris motor; (*b*) input signal amplifier; (*c*) signal from measuring element; V_{exc} = excitation voltage; C_{exc} = condenser; V_c = control voltage.

Normally, there is no ohmic connection between the amplifier output of the measuring stage and the excitation circuit. It is possible, therefore, to provide a motor with a more efficient utilisation of material than previous types, this being achieved by designing the motor with a closed symmetrical system of stator windings. The phases V_{exc} and V_c of the excitation and the control voltage respectively are applied at diametrically opposite points, as in a bridge circuit.

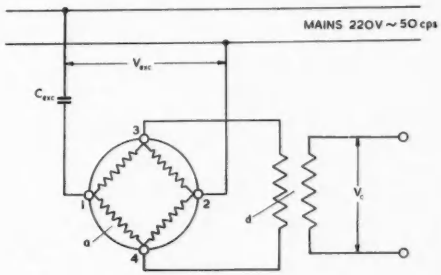


Fig. 3. **Ferraris motor with closed annular winding in control circuit.**
(*a*) Ferraris motor; (*d*) transformer; V_{exc} = excitation voltage; C_{exc} = condenser; V_c = control voltage.

Two different arrangements are shown in Figs. 2 and 3. In the first, the terminals 3-4 of the control voltage can also be connected directly to the mains supply (provided that the windings are designed for this voltage). In the second case, a transformer with separate primary and secondary windings is required.

OPERATION OF THE FERRARIS MOTOR

The operation of the motor may be described by considering a particularly simple example. Fig. 4 shows sectional drawings of the stator windings. The winding 1-2 is the exciter winding, connected to the mains voltage by means of a condenser C_{exc} (see Fig.2) and carrying a current I_1.

The winding 3-4, at right angles to 1-2, is connected to the source of control voltage and carries a current I_2. The capacitance of C_{exc} is so determined that the currents I_1 and I_2 will have a phase difference of 90 deg, with I_1 leading I_2. The current variations can thus be expressed by the equations

$$I_1 = I_{1\max} \cos \alpha \quad \text{and} \quad I_2 = I_{2\max} \sin \alpha \qquad (1)$$

The magnetic flux Φ_1 produced in the stator by the current I_1 and the flux Φ_2 due to I_2 combine to give a resultant flux Φ_{res}. Relating each flux to its corresponding current by means of a proportionality factor k, so that $\Phi_{1,2} = kI_{1,2}$, the resultant flux is obtained as

$$\Phi_{res} = k\sqrt{I_1^2{}_{\max} \cos^2 \alpha + I_2^2{}_{\max} \sin^2 \alpha} \quad .. \qquad (2)$$

and in the particular case where the peak values of current are equal, so that $I_{1\max} = I_{2\max} = I_{\max}$, the resultant flux becomes

$$\Phi_{res} = kI_{\max} \quad .. \quad .. \quad .. \qquad (3)$$

This equation shows that under the above conditions a magnetic flux of constant magnitude for all values of α is obtained. However, the angle of the direction of the flux relative to a fixed reference direction (e.g., the line joining the centre point to point 1 in Fig. 4a) varies according to the instantaneous phases of the currents.

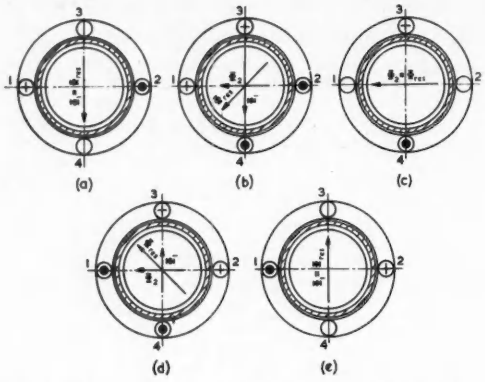


Fig. 4. **Operating principle of Ferraris two-phase motor.**

The result is, therefore, a rotating magnetic field with a flux vector rotating at a constant angular velocity

$$\omega = 2\pi f = d\alpha/dt = \text{constant} \quad .. \quad (4)$$

where t = time and f = frequency of the alternating currents I_1 and I_2 in the stator windings of the motor. If the polarity of the terminals of winding 3-4 is reversed, the direction of rotation of Φ_{res} also reverses. As a result, the direction of rotation of the motor is reversed.

To obtain a clear idea of the way in which torque is produced, consider two horizontal elements and two annular end elements of the drum-type rotor, as shown in Fig. 5. These may be regarded as being cut out of the rotor body, and form a closed loop which is traversed by the external rotating field, i.e., by the flux Φ_{res}, which is variable relative to the (horizontal) plane

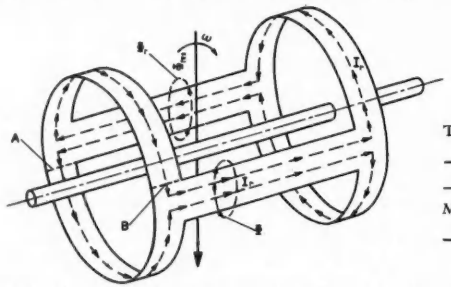


Fig. 5. **Fluxes and induced currents in the rotor of a Ferraris motor.**

of the loop. If the loop were cut open at the positions marked A and B, it would be possible to measure the voltage induced in it. However, as the elements considered form a closed path, there is a flow of current I_r in the loop, owing to the voltage induced by Φ_{res}, as shown by the arrow lines in Fig. 5. This current is associated with a magnetic field which tries to reduce the external field, so that the corresponding rotor flux Φ_r opposes Φ_{res}, as indicated in the figure. The rotating flux Φ_{res}, however, is maintained by a powerful external source of energy, so that the conductors of the loop will tend to turn away in a direction reducing the induced voltage. This motion results, therefore, in mechanical forces and torque. If the loop is able to move freely without being subjected to a load torque, it will speed up until its torque is in equilibrium with the resisting torques due to bearing friction, windage, etc. The rotary speed of the loop will always be, however, somewhat lower than that of the rotating field, since, if both speeds were equal, there would be no induced voltage with Φ_{res} at a constant angle. The system thus operates as an asynchronous motor and rotates in the same direction as Φ_{res}.

Ferraris motors usually have a bell-type rotor, which can be imagined to be made up of a large number of elements assembled as shown in Fig. 5. The induced currents will not then flow along clearly defined paths as in the above figure, but will be distributed according to the geometry and conductivity of the rotor design. These eddy currents cannot be determined as regards magnitude or direction by technical measurements. Ferraris motors are thus of the eddy-current type, which also includes the well-known squirrel-cage induction motor.

The electromagnetic processes in the Ferraris motor having thus been considered in detail, it is easily seen that, with the field rotating at a constant velocity, the torque will depend on the rotor speed and the magnitude of the resultant flux. The torque has its maximum value at zero rotor speed, as the relative velocity between the field and the rotor is then greatest. However, a reduced torque can be obtained, if necessary, by altering the 90-deg phase angle between the currents I_1 and I_2, in which case the resultant flux is no longer of constant magnitude. Similar conditions can be obtained if the two windings 1-2 and 3-4 are not kept at right angles to each other. Therefore, it may be stated that the torque T of the Ferraris motor is proportional to the partial fluxes Φ_1 and Φ_2 and their relative phase angle γ:

$$T = k\,\Phi_1\,\Phi_2 \sin\gamma \quad .. \quad .. \quad (5)$$

k being a proportionality factor. The expression, sometimes found in literature,

$$T = k\,I_1\,I_2 \sin\beta,$$

where β = phase angle between I_1 and I_2, is valid only if the windings are invariably situated at right angles to each other, whereas eq. (5) covers the general case. The torque, therefore, can be regulated by varying either a current or a phase-angle value. In general, it is usual with control systems to vary only the amplitude of one of the phase currents. The speed variation of the Ferraris motor is a linear function of the control voltage over a wide range of speeds, as can be seen from the following table:—

TABLE I. SPEED CHARACTERISTICS OF THE FERRARIS MOTOR AS A FUNCTION OF THE CONTROL VOLTAGE.

Control voltage V_c	43	50	60	72	80	100	120	140
Motor speed [rpm] (a)	0	350	800	1250	1600	1950	2200	2300
Motor speed [rpm] (b)	—	—	—	0	400	1300	1750	1900

(a) = shaft torque of 550 gr-cm ; (b) = shaft torque of 1000 gr-cm.

OPERATING CHARACTERISTICS

It is interesting to consider the advantages to be gained by using Ferraris motors instead of other motors in control systems. Compared with d.c. machines, which have inherently good control characteristics, and a.c. commutator machines, the Ferraris motor, like the slipringless a.c. induction motor with solid armature, requires no brush gear. Brushes are subject to wear and require constant maintenance. Where sparkless operation is necessary, the special shielding represents a considerable expense. Compared with the a.c. motor, which has its rotor winding embedded in core disc packets, the Ferraris has a rotor of simpler design, consisting of a thin-walled aluminium drum, with a rotor inertia about one-tenth or less than that of a conventional induction motor of similar power output.

Oscillographic recordings show that the control-current reversal occurs in 0·04 sec with a Ferraris motor, whereas the armature-current reversal from clockwise to anti-clockwise rotation of a shunt-wound d.c. motor takes 0·19 sec at full speed. Furthermore, the low moment of inertia of the rotor makes it possible to stop

the motor suddenly, without causing high impact loads on other components of the drive, so that in control systems with properly designed drive elements, end position switches may be eliminated.

In order to have an idea of the magnitude of the forces involved in a sudden stopping of the power unit, consider the following example:—A throttle valve requires a regulating torque of 30 kg-metres. The valve linkage is connected to the positioning unit by a crank arm of 20 cm in length. A comparison will be made of two types of drive motors:—(a) An asynchronous motor of the usual solid-armature type with a nominal speed of 1500 rpm, and (b) a Ferraris motor of equivalent shaft power at 1500 rpm. The reduction gear between the motor and the crank is of the spur-gear type, with a final gearwheel of 150 mm diameter fitted on the crank element.

This gearwheel is subjected to the greatest loads and will be used as a basis for comparison. Disregarding gear efficiencies, from the values given above, a force of $30/0{\cdot}2 = 150$ kg is required to operate the valve linkage, corresponding to a tooth pressure of 400 kg. These data are usually sufficient to determine the elements of the drive.

It is necessary to avoid any possibility of impact of the throttle valve against its stops, caused by the inertia torque of the armature at high motor speeds, and limit switches are normally provided in order to switch off the drive motor a short time before it reaches the end of its travel. The actual force of impact depends on the general design of the drive and the particular operating conditions, but it is possible to determine the relative forces required for sudden braking. For this comparison it will be assumed that the throttle valve is moving at full speed towards its end position and that the braking length before the stops is $s = 0{\cdot}25$ mm. The tooth-impact force F is determined from the relation

$$F = \mathcal{J}\,\omega^2/s$$

where $\mathcal{J}$ = moment of inertia and $\omega = 2\pi n/60$ = angular velocity [rad/sec], n being the motor speed (1500 rpm).

(a) For the asynchronous motor, with $\mathcal{J} = 2{\cdot}6$ gr cm sec^2, the impact force is F = 1300 kg.

(b) For the Ferraris motor, $\mathcal{J} = 0{\cdot}26$ gr cm sec^2, so that the impact force is F = 130 kg.

In case (a) the force is well above permissible values, whereas in case (b) the impact is still within the usual limits of safety based on operating experience. In the latter case, therefore, end-position switches are not needed.

As control motors incorporated in drives are frequently exposed to severe working conditions, Ferraris motors are built as fully-enclosed power units, which are not affected by water splash. As, in all such machines, the cooling conditions are therefore unfavourable and it is necessary to consider the room temperature at which the motor is used, the windings of the Ferraris motor are carefully impregnated under vacuum, so that this design can operate up to 95° C, which corresponds to a temperature margin of 75° C at 20° C ambient temperature, or 55° C at an ambient temperature of 40° C. The temperature rise under continuous-running conditions as a function of power inputs is shown in the following table:—

TABLE II. TEMPERATURE RISE IN A FERRARIS MOTOR UNDER STANDSTILL CONDITIONS

Power [W]		0	50	80	100	150
Temperature rise [°C]	(a)	38	63	82	—	—
	(b)	0	32	51	63	83

(a) = temperature rise as a function of control power P_c, with excitation $P_{exc} = 60$ W, and (b) = temperature rise as a function of total power $P_{total} = P_{exc} + P_c$.

The temperature values shown in this table were measured on a motor which was suitably mounted on a gearbox so as to dissipate heat by conduction to other surfaces. This arrangement is frequently employed and the above values can therefore be used to assess optimum power for this type of motor in any applications.

The excitation circuit of the motor (C_{exc} and V_{exc} in Fig. 3) is designed to give maximum torque as soon as the control voltage is switched on, this being a usual requirement. When the motor operates in a control system, the friction of the stationary machine also has to be considered. The torque variation as a function of speed is shown in Fig. 6 for various values of the control voltage. The torque decreases slowly at first and then more rapidly at high speeds. The starting torque increases proportionately to the control voltage supplied to the second phase, that is, it is proportional to the amplified value of voltage representing the measured quantity. The starting torques for various conditions are given in the table below.

TABLE III. STARTING TORQUE OF A FERRARIS MOTOR FOR 30 W NOMINAL POWER.

V_c [V]	0	50	100	150	200	225
P_{total} [W]	60	65	77	100	130	150
P_c [W]	0	5	15	40	72	90
T_s [gr-cm]	0	720	1440	2160	2880	3240

P_c = controlling power, P_{total} = total power input, T_s = starting torque, and V_c = control voltage. Operating conditions:—Constant excitation $V_{exc} = 225$ volts, and $C_{exc} = 4\,\mu F$.

Fig. 6 and the above table can be used to determine the range of utilisation of a motor and other data required for its operation. The following example illustrates the manner in which they are applied:—

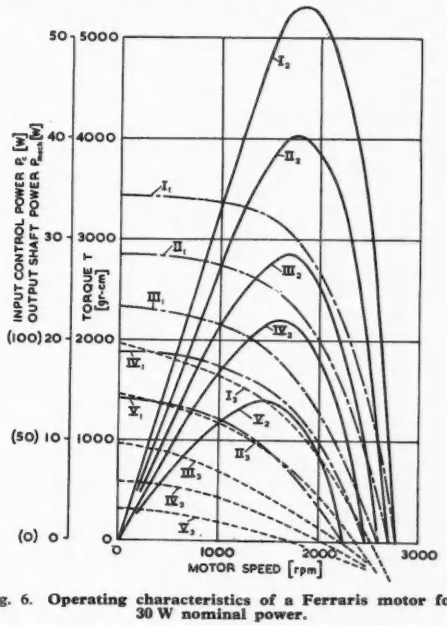


Fig. 6. **Operating characteristics of a Ferraris motor for 30 W nominal power.**

Torque T, shaft power P_{mech}, and control power P_c plotted against motor speed.

V_c [volts]	234	200	162	130	96
T [gr-cm]	I_1	II_1	III_1	IV_1	V_1
P_{mech} [W]	I_2	II_2	III_2	IV_2	V_2
P_c [W]	I_3	II_3	III_3	IV_3	V_3

Excitation voltage $V_{exc} = 220$ V; $C_{exc} = 4\,\mu F$.

A Ferraris control motor is to be used in a room with an ambient temperature of 20° C and operated up to the maximum temperature of 95° C. It is mounted on a gearbox or any other large surface with good heat-conducting properties. From Table II the control power can reach up to 75 W, and Table III shows that this corresponds to a control voltage of about 200 V. This voltage, from the curves in Fig. 6, gives a starting torque of 2800 gr-cm and a maximum shaft power of 40 W for continuous operation. At 40° C ambient temperature, the available torque is about 2250 gr-cm and the maximum shaft power is approximately 23 W. Thus, ambient temperature is a major factor, and this is true for any type of electric motor. The above values are based on the assumption that the motor is always connected to the control voltage, though this is not usually the case in control systems. However, as the time/load characteristic of a control motor cannot be fully determined in practice, it is advisable to base performance figures on the most unfavourable conditions, as in this example, to avoid exceeding the temperature limit.

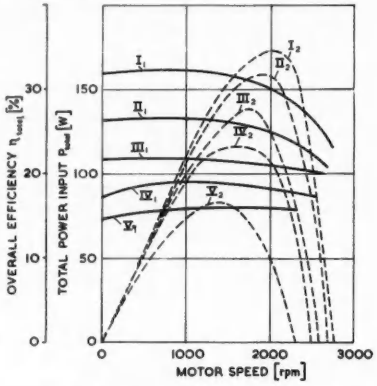


Fig. 7. **Total power input P_{total} and overall efficiency η_{total} characteristics, plotted against motor speed.**

V_c [volts]	234	200	162	130	96
P_{total} [W]	I_1	II_1	III_1	IV_1	V_1
η_{total} [%]	I_2	II_2	III_2	IV_2	V_2

If no control voltage is applied, the motor will warm up, owing to the power continuously supplied from the mains to the excitation phase, and it will reach a temperature level about 35° C above ambient temperature. With the circuit arrangement shown in Fig. 3 and the values in Table III, this corresponds to an excitation power of about 60 W. This latter value has been used as a basis for the above examples, as well as for performance characteristics.

Fig. 6 also gives curves for the control power. These curves decrease with increasing motor speed and even become negative in the neighbourhood of zero-load speed. The excitation power, however, increases with speed, and the total power input (i.e., the sum of control power plus excitation power), which is the decisive factor as regards heat generation, remains fairly constant for small and medium values of control voltage. A decrease in total power input at high speeds is obtained only with high control voltages (see Fig. 7). In control systems, the motor generally operates at low or medium speeds and hence the drop in total power has no practical influence on the thermal loading. The shape of the curve for control power, shown in Fig. 6, is important for determining the size of motor and for assessing the load characteristics of the amplifier in the control stage.

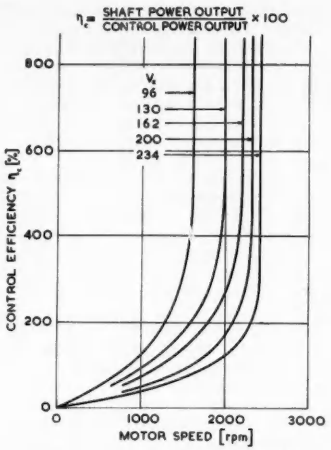


Fig. 8. **Curves of control efficiency η_c plotted against motor speed, for different control voltages V_c.**
η_c = shaft power output/control power input.

Fig. 7 shows curves of total power and overall efficiency (i.e., shaft power as a percentage of the total power input) plotted against engine speed.

Although the curves in Fig. 7 give efficiency characteristics which can be used for comparisons with those of other small-size motors, the specialist in control systems is primarily interested in the "control efficiency," i.e., the ratio of shaft output power to the input control power taken by the motor. Curves of this type are shown in Fig. 8, and indicate that, at higher speeds, the Ferraris motor has characteristics comparable with those of "amplidyne" motors produced in recent years.

DUST AND FUME PROBLEMS IN THE STEEL INDUSTRY

(*Concluded from page* 459)

Pickling Plant

Modern installations of continuous-type pickling plant are usually provided with a ventilating system to remove fumes and these are ordinarily exhausted to the atmosphere through rubber-lined flues and fans. Since these gases rarely get beyond the confines of the plant property, any nuisance involved is generally an inter-plant problem.

Powdered Fuel Heating Furnaces

Powdered fuel heating furnaces for large forgings and the like can be provided with mechanical collectors to recover the majority of the fly-ash. These are installed and are currently being used in some plants.

Summary

The making of steel is not a clean operation by any means, and all operations are carried out on a large scale. This makes any dust recovery problem both costly and more difficult to handle.

The steel industry has the widest range of dust problems in any industry, and dust collector manufacturers and steel plant engineers have a lot to learn in the development of satisfactory solutions.

There are more dust collectors of more varied types and kinds in steel plants than in any other industry.

A good start has been made, and with the present co-operation by engineers in the steel industry, dust collector manufacturers and, particularly, smoke inspectors, much will be accomplished in the immediate years ahead.

The New Cryogenic Laboratory of The National Bureau of Standards

(From *Technical News Bulletin, National Bureau of Standards*, Vol. 37, No. 10, October, 1953, pp. 152-158, 11 illustrations.)

LOW-TEMPERATURE liquefied gases—oxygen, hydrogen, and nitrogen—are finding increased application in industry and national defence, making necessary larger, more convenient, and less hazardous equipment for producing and handling these liquids. At liquid-hydrogen temperatures, normally trustworthy constructional steels become brittle, rubbers lose their elasticity, and the mechanical properties of plastics are greatly altered. In general, there are such marked differences between the behaviour of matter at ordinary and very low temperatures that the low-temperature properties cannot be obtained by extrapolation.

The new NBS-AEC Cryogenic Engineering Laboratory, operating on the National Bureau of Standards site at Boulder, Colorado, makes possible large-scale production of liquefied gases which have not previously been available in sufficient quantity for laboratory and industrial development and testing. Here, investigations are being made into structural and other engineering properties of matter at low temperatures, to provide needed data and to develop more satisfactory materials and equipment for low-temperature use. The Bureau's long-standing programme of fundamental research on the properties of liquid helium, super-conductivity, second sound, paramagnetism, and other phases of low-temperature physics remains at the NBS Washington laboratories.

The new laboratory consists of three principal units :—A liquid hydrogen plant, a liquid nitrogen plant, and a group of laboratories for research and development. There are also several auxiliary buildings and test sites.

HYDROGEN LIQUEFACTION

Commercial hydrogen is transported to the NBS plant for liquefaction in mobile tube tanks. The hydrogen is stored in these and in similar stationary tube banks at the Laboratory at a pressure of 2,100 to 2,400 psi until needed in the plant. From the storage tubes, the gas flows at reduced pressure (25 to 50 psi) through a tank containing a palladium catalyst, which removes small amounts of oxygen, and then to water-cooled four-stage compressors, as shown in Fig. 1. Two 3,000-cu ft gas holders in the line between the deoxidising equipment and the compressors provide a ballast for operation of the plant and also serve to maintain a small pressure in the line.

Leaving the compressors at room temperature and a pressure of about 2,000 psi, the gas is next purified by means of a system consisting of oil-water separators to remove suspended liquid, a refrigeration drier to remove water and oil vapour, and an adsorption purifier of silica gel cooled to liquid nitrogen temperature, for removal of nitrogen and other gases. After the purified hydrogen has given up some of its heat energy in passing through counterflow heat exchangers, further cooling is attained in the liquid-nitrogen precooler, where the hydrogen passes through coiled tubing immersed in liquid nitrogen boiling at reduced pressure. From the precooler, the gas passes through a final heat exchanger and then through the Joule-Thomson expansion valve, where part of the hydrogen is liquefied by the expansion.

Upon leaving the liquefier, the liquid hydrogen is transferred into storage containers through specially designed vacuum-insulated transfer lines. These " pipelines " have been used to carry the liquid 50 ft or more, and it appears likely that this distance can be greatly extended if desired.

The NBS hydrogen liquefier is unique in that all the heat exchangers as well as the liquid-nitrogen precooler are contained in a single large vacuum-insulated metal dewar having an internal length of 90 in. and an internal diameter of 30 in. An identical dewar surrounds the silica-gel adsorption purifier. Inasmuch as the hydrogen liquefying equipment is in duplicate and each liquefier is provided with two silica-gel purifiers for alternate use, the hydrogen plant contains six of the large dewars altogether.

The upper two-thirds of the liquefier dewar, shown schematically in Fig. 2, contains three heat exchangers and the liquid nitrogen precooler. These heat exchangers

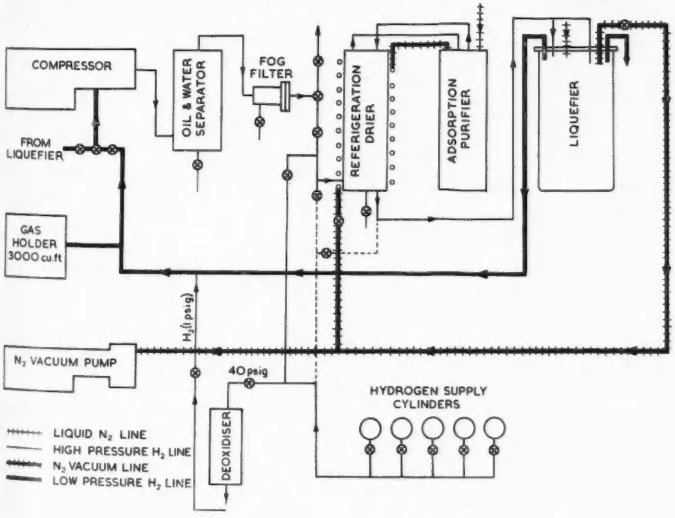


Fig. 1. **Flow diagram of hydrogen liquefier.**

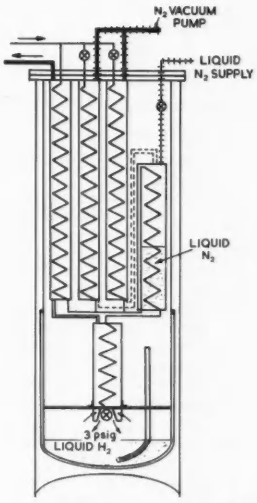


Fig. 2. **Schematic layout of hydrogen liquefier.**

are in parallel and are equipped with adjusting valves permitting distribution of the flow of incoming hydrogen between the exchangers in such a way as to obtain maximum efficiency in the cooling process. The lower third of the liquefier dewar serves as the liquid hydrogen collection pot. It also contains the final heat exchanger and the Joule-Thomson expansion valve. The portion of the hydrogen which was cooled but not liquefied in passing through the expansion valve is used as a refrigerant in the final heat exchanger and in one of the initial heat exchangers, while the liquid nitrogen vapour from the pre-cooler is the refrigerant in the other two heat exchangers.

The refrigeration drier and silica-gel adsorption purifier are arranged as a unit. Hydrogen gas enters the drier case at room temperature and passes over heat-exchanger tubes, where it is cooled by outflowing gas inside the tubes. The water and oil impurities are condensed out as the gas flows through the drier towards the nitrogen purifier. The gas is finally cooled to liquid nitrogen temperature by passing through a coil immersed in liquid nitrogen in the purifier dewar. At this temperature nitrogen gas, present as an impurity in the hydrogen, is readily adsorbed by the silica gel as it flows through the silica-gel coil.

For efficiency and convenience of operation, the hydrogen liquefaction system is extensively equipped with automatic instruments, recording devices, and servomechanisms. The nitrogen content of the hydrogen is measured by a special thermal-conductivity apparatus, and whenever a part of the liquefaction plant is not operating properly, a general annunciation system rings a bell and flashes a light indicating the particular part of the equipment that must be investigated.

Nitrogen Liquefaction

Liquid nitrogen (99·7 per cent pure) for precooling the high-pressure hydrogen in the liquefier is produced in the liquid nitrogen plant, which consists of two complete and independent commercial units for purifying and liquefying the gas. Both units are usually operated simultaneously. Two 11,000-litre insulated storage containers, each having a loss rate of about 1·5 per cent a day, make it possible to maintain a large supply of liquid nitrogen at all times.

At atmospheric pressure, nitrogen must be cooled to − 196° C for liquefaction. In the NBS plant liquefaction is attained a few degrees above this temperature because the pressure of the gas is kept somewhat higher. During the course of the process, nitrogen is separated from ordinary air drawn in from the roof of the plant and is ultimately cooled to liquefaction by a combination of processes involving refrigeration by contact with colder gases flowing back from later stages of the cycle, expansion through a Joule-Thomson valve and through an air-expansion engine, and fractional distillation for removal of oxygen and further liquefaction.

The air from which the nitrogen is to be separated is first compressed to 3,000 psi in five stages. Between the second and third compression stages it is run through a tank containing a solution of sodium hydroxide for removal of carbon dioxide (see Fig. 3). After three more compression stages have brought the pressure to 3,000 psi, the gas flows through a drier containing activated alumina for removal of moisture.

With carbon dioxide and water removed, the gas now consists essentially of nitrogen and oxygen at relatively high pressure. It next enters a heat exchanger which it leaves by two different lines. One line is connected to the cold end of the heat exchanger (about − 145° C), the other being connected at a point where the temperature is about 0° C. Through this latter line the high-pressure gas enters an expansion engine. Here its pressure is lowered as it does work against reciprocating pistons. The work thus developed is absorbed by an electric generator, and this loss of energy from the gas results in a lowering of its temperature to about − 140° C. Further temperature reduction down to the liquefaction point is then obtained by passage through an auxiliary low-pressure heat exchanger.

The line leaving the cold end of the main heat exchanger goes to an expansion valve, where the pressure is reduced to about 5 atmospheres. The temperature

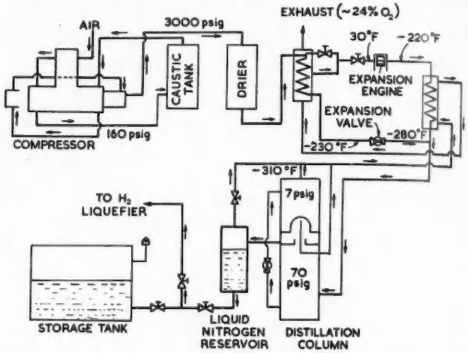


Fig. 3. **Flow diagram of nitrogen liquefier.**

is correspondingly reduced to the liquefaction point by the Joule-Thomson cooling effect, causing a fraction of the air to liquefy.

The expansion engine furnishes a considerable amount of refrigeration which indirectly serves to precool the air going to the expansion valve, thereby increasing the efficiency of the process by several times. Optimum performance of the system is obtained by regulation of the amount of air taken by the expansion engine. This is controlled by the speed of the expansion engine and the time the intake valve is open.

The two streams of partially liquefied nitrogen-oxygen mixture join and flow to a distillation column, where the liquid nitrogen is separated from the mixture. Refrigeration for condensation of the nitrogen vapour accumulating in the top of the distillation column is obtained by piping some of the oxygen-rich liquid in the bottom of the column into a jacket surrounding the top of the column. The liquid nitrogen is continuously tapped off into a reservoir and periodically transferred to the large storage tanks.

Safety Devices

Among the many automatic safety devices in the new laboratory is a hydrogen-gas indicator, which continuously samples the air at eight points throughout the plant building. Whenever the hydrogen concentration reaches 10 per cent of the lower explosive limit, this device sounds an alarm and automatically closes off all sources of hydrogen. In addition, a ventilating system has been installed which normally changes the air in the building every 2 minutes and is automatically speeded up to effect a complete change once a minute when the hydrogen alarm sounds. Other safety precautions include conductive floors to eliminate static sparks, a system which measures the concentration of oxygen in the hydrogen with a sensitivity of 2 ppm, and means for venting hydrogen in an emergency.

Research and Development

Research and development at the NBS-AEC Cryogenic Engineering Laboratory are directed principally toward safer and more convenient means for handling liquid hydrogen and towards increased knowledge of the properties of materials at very low temperatures. Efficient design of low-temperature equipment requires information on the mechanical and

heat-conducting properties of many metals, alloys, and plastics over a temperature range extending from room temperatures down almost to absolute zero. The Bureau is now developing apparatus for low-temperature measurement of the tensile and impact behaviour and fatigue properties of these materials. Such data are at present meagre and are mainly confined to those materials and temperatures encountered in aircraft design. As a first step towards the accumulation of thermal conductivity data, apparatus has been designed providing results in the temperature range from 2° to 300° K. The new apparatus is expected to make possible more rapid collection of data without loss of accuracy.

Design of a large-capacity cryostat is also under way. This equipment will be used to provide a controlled low-temperature environment for many different kinds of tests of low-temperature materials.

The Bureau is also working on the design of more efficient insulated lines for transfer of liquefied gases. A major part of this project is the development of valves, fittings, and couplings permitting easy assembly, extension, and control of flow.

Recently, the efforts of the Bureau to obtain liquid parahydrogen on a large scale have met with signal success. Liquid hydrogen as usually produced has a high concentration of the molecular form known as orthohydrogen, in which the diatomic molecules have the two nuclear spins oriented in the same direction. But the low-temperature equilibrium form of hydrogen is nearly pure parahydrogen, in which the nuclear spins in each molecule are opposed. Thus, ordinary liquid hydrogen slowly changes to the *para* form with an accompanying evolution of heat, and this heat causes a serious loss of liquid hydrogen by evaporation (about 1 per cent per hour for fresh normal liquid hydrogen). One of the liquefiers at the Cryogenic Engineering Laboratory has been equipped with a special catalysing chamber which results in the production of almost pure liquid parahydrogen. This liquid hydrogen, being free from exothermic *ortho-para* conversion, has excellent keeping qualities and can be stored with little loss for many days.

U.S.A.

Non-Corrosive Soldering Fluxes

By W. S. GALE. (From *The Iron Age*, Vol. 172, No. 10, September 3, 1953, pp. 115-119, 9 illustrations.)

ONE of the pre-requisites of soldering is the formation of an alloy system between the solder and the metals being joined. To accomplish this, the surfaces of the metals to be joined must be chemically cleaned during soldering to remove completely any interfering films or oxides.

A fluxing agent is usually required to prepare the metal surfaces. Zinc chloride or mixtures of zinc chloride and ammonium chloride have been used for this purpose for centuries.

When zinc chloride fluxes are heated during soldering, water is driven off, depositing the flux salts. Further heating causes these salts to melt. While molten, the salts have the ability to dissolve oxides and other interfering films from the surfaces of a number of metals.

The molten salts maintain a protective coating over the heated metal surfaces, thus preventing the oxide films from re-forming. The solder, when melted, displaces the fused flux from the metal surfaces and alloys with the metals being joined.

Zinc chloride, as a flux, has some objectionable characteristics. Foremost among these is that zinc chloride deposits fused residues which remain within or surrounding the soldered joint. These residues cause severe corrosion unless quickly removed.

Owing to the nature of these residues, it is difficult or impossible to remove them satisfactorily. Often their corrosive action cannot be tolerated. Even though every precaution is taken to remove as much of the residues as possible, it is sometimes necessary to resort to washing in dilute acid to remove the more stubborn deposits.

A second major disadvantage of zinc chloride fluxes is that the fumes evolved during soldering have a very corrosive action on jigs, fixtures, and other plant equipment. Furthermore, if improperly used, the raw flux and its fumes may constitute a health hazard.

Zinc chloride fluxes are by no means universal in the sense that they cannot be used effectively to promote the soldering of many common metals and alloys. For example, they will not remove the oxide coating from aluminium.

A research programme for the purpose of developing an effective non-corrosive flux was initiated in 1947 by the McCord Corporation, of Detroit, U.S.A., overall requirements for a perfect flux being the following :—

(1) The flux should be molten at temperatures below the solidus temperature of the solder and should remain in a fused condition throughout the plastic range and until the molten solder has ceased to flow.

(2) It should be capable of removing oxides and other interfering films from the metals to be joined by reacting with these oxides, films, and coatings, either to dissolve, reduce, or remove them.

(3) It should prevent re-oxidation of the metal surfaces during soldering.

(4) It should be capable of being displaced from the metal surfaces by the solder and should serve to reduce the surface tension of the molten solder.

(5) It should leave, within or surrounding the soldered joint, no residues which would promote corrosion of the joint or the bonded metals.

(6) Its use should introduce a minimum of health hazards.

Eventually, a flux was developed possessing all these characteristics to a marked degree. It depended for its fluxing action upon the use of compounds of hydrazine (N_2H_4), a chemical which was used as a rocket fuel by the Germans in World War II.

The new hydrazine fluxes proved considerably more effective than zinc chloride in the soldering of copper and brass, and carefully controlled tests showed that hydrazine fluxes had, in some cases, more than twice the solder-spreading action of zinc chloride.

A few radiators were manufactured from copper and brass using the new hydrazine fluxes. Severe testing showed that excellent soldering had been obtained and that no corrosive residues were left on the metals. Since then the new fluxes and soldering processes have been used in making over 2 million copper and brass automotive heat exchangers, not only by the McCord Corporation, but also by the Ford Motor Co.

When the new flux is heated to soldering temperature, the hydrazine compounds decompose harmlessly into nitrogen and ammonia, and no corrosive residues are left behind. Humidity tests revealed that hydrazine fluxes satisfied the requirements set forth in U.S. Army and Navy specifications for neutral or non-corrosive fluxes.

SOLDERING ALUMINIUM

Early in the research programme, it was discovered that the new fluxes could be used to solder aluminium. In the past, the utility of aluminium has been restricted

by the difficulty of joining aluminium to itself and to other metals. There are two reasons for this, *viz.* :— (1) The heavy oxide coating normally found on aluminium defies removal by the common fluxes. This made it difficult to weld or braze, and almost impossible to solder; and (2) when aluminium is joined to dissimilar metals, conditions are present which may cause galvanic corrosion of the joint or of the aluminium.

As a result of an intensive investigation into the aluminium soldering problem, several non-corrosive fluxes were developed, permitting effective soldering of aluminium to itself and to other metals, with a wide variety of solders, using many of the common, mass-production soldering methods.

McCord engineers believed it might be possible to make radiators with aluminium cooling fins soldered to conventional brass or copper water-carrying tubes. By substituting aluminium for copper in the fins alone, it would be possible to eliminate an average of 8 to 10 lb of copper per radiator. Another advantage of such a composite structure would be that all the surfaces in contact with the coolant would be of the same time-proven metals which have regularly been used. In this way, concern over the electrolytic effect on aluminium of water containing heavy metals would be eliminated.

The concept of the soldered aluminium-fin radiator has proved to be practical. Test cars equipped with these radiators have been operating for more than a year over thousands of miles. The heat transfer capacities of the aluminium-fin radiators are equivalent to those of the conventional radiators they replaced. Their performance has been checked regularly ; not one has been returned for service from the field.

The new fluxes have found important applications outside the heat-exchange industry. They are used to solder parts of heavy-duty electric motors with lead solders containing small percentages of silver. For instance, one supplier of electronic equipment found that use of the fluxes improved his product and reduced production costs. In another case, a manufacturer of carburettor floats found that the zinc chloride flux used to solder the brass floats together often etched pin-holes in them. Since using these fluxes in this operation, the manufacturer has eliminated considerable testing and a costly washing operation.

McCord's aluminium soldering process has been used to solder aluminium or brass terminals to aluminium electrical conductors, such as battery cables. Dozens of aluminium battery cables were installed on test cars for periods of several months, with satisfactory results, so much so that two automobile manufacturers have approved the use of aluminium ignition and battery cables soldered by this method.

McCord has recently worked with an automotive manufacturer in the application of the fluxes to several soldering problems. One aspect of this work is an armature with aluminium windings, soldered to copper commutator sections. Assembled into a starting motor, the unit has been satisfactorily undergoing tests for several months.

The new fluxes, which are readily applicable as water solutions or in the form of pastes, have been named Coronil soldering fluxes and the process of using them is known as the Coronil soldering process. The McCord Corporation does not plan to manufacture or sell these fluxes, but prefers to make them and the processes available through a licensing programme.

SWEDEN

The Influence of Primary Creep on Stresses in Structural Parts

By F. K. G. Odqvist. (From *Acta Polytechnica*, Mechanical Engineering Series, Vol. 2, No. 9, 1953, 17 pages 10 illustrations.)

The object of this paper is to show how primary creep may be taken into account within a purely phenomenological theory, capable of extension to general three-dimensional stress systems. The new theory may also explain part of the deviations of experiments from older theories.

Theories of stationary creep under combined stresses have long been developed[1, 2, 3, 4]. Generally, they give relations between the strain rates and the state of stress, the constants being determined from, for instance, tension tests under constant load. Recent accurate experiments[5, 7] give some preference to the simpler of these theories[1, 3].

As highly creep-resistant alloys have been developed (e.g., for high temperature service, such as in gas turbines and jet engines), the limiting creep stress has gradually increased in comparison with the ordinary yield stress of the material at the same temperature. This fact has increased the importance of primary creep compared with the total amount of creep within the service life of a structural element. Thus, in applying theories of combined stress to such structural parts as the rotating discs of gas turbines, it has become necessary to take account of primary creep, in order to get a true picture of the stress distribution of the disc[8].

Fig. 1 shows the usual appearance of a creep curve at constant uni-axial stress, if total strain ϵ is plotted against time t. OA is the instantaneous elastic strain and AB the accompanying plastic strain. Generally, AB is much greater than OA. AC, CD, and DE denote the stages of primary, secondary, and tertiary creep, according to the accepted terminology. The theories of combined stresses have hitherto taken into account only the part CD of the curve, where $d\epsilon/dt$ is a constant. The implication is that ϵ_D has been considered large compared with ϵ_C, and this is by no means the case generally, most certainly not for creep-resistant alloys.

Taking account of primary creep means to make creep stress depend on total strain as well as, independently, on strain rate.

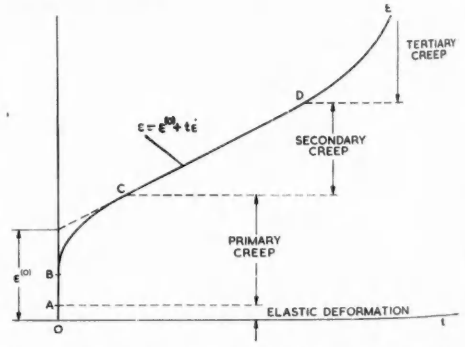


Fig. 1. **Total strain ϵ as a function of time t for creep tests at uni-axial constant tension stress.**

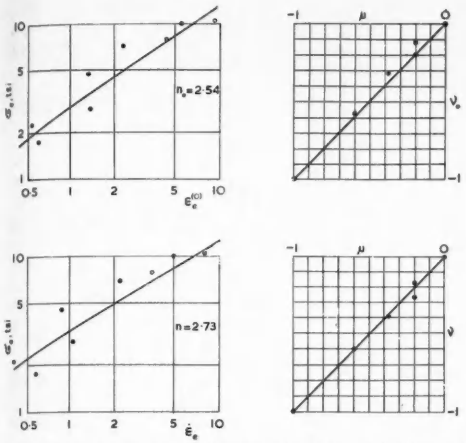


Fig. 2. **Experimental verification of eqs. (5), (6), (10), and (11) for Nimonic 75 at 650° C.**

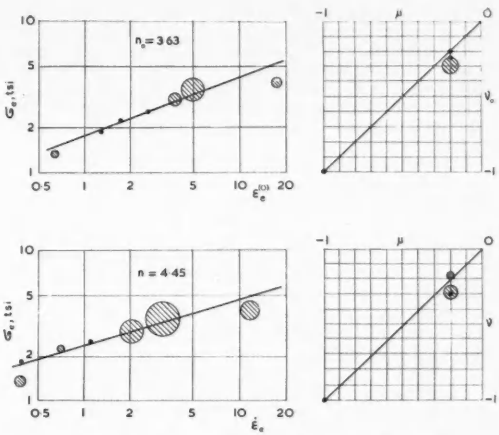


Fig. 3. **Experimental verification of eqs. (5), (6), (10), and (11) for magnesium at 50° C.**

Consider an ordinary creep test in uni-axial tension at constant stress, according to Fig. 1. Simplifying, total strain is

$$\epsilon = \epsilon^{(0)} + t\,\dot{\epsilon} \qquad .. \qquad .. \qquad (1)$$

where $\epsilon^{(0)}$ is the strain at time $t = 0$, and $\dot{\epsilon}$ the constant strain rate. The quantities $\epsilon^{(0)}$ and $\dot{\epsilon}$ depend on stress and temperature only.

For three dimensions the following notations, with summation convention and δ_{ij} = Kroneckers symbol, are used:—

σ_{ij} = stress tensor. Then, σ_{kk} may be taken as a shorthand notation for $\sigma_{11} + \sigma_{22} + \sigma_{33}$, and $\sigma_{ij}^2 = \sigma_{11}^2 + \sigma_{12}^2 + .. + \sigma_{33}^2$, and so on.

s_{ij} = " stress deviation " $= \sigma_{ij} - \delta_{ij}\,\sigma_{kk}/3$,

ϵ_{ij} = strain tensor,

$\sigma_e = (3\,s_{ij}^2/2)^{1/2}$ = " effective stress,"

$\epsilon_e = (2\,\epsilon_{ij}^2/3)^{1/2}$ = " effective strain."

By neglecting the accompanying elastic deformation and assuming creep to take place without volume change, $\epsilon_{kk} = 0$.

Two different theories will be investigated separately:

THEORY I

$$\frac{d\epsilon_{ij}}{dt} = f(\sigma_e)\,s_{ij} + g(\sigma_e)\,\frac{ds_{ij}}{dt} \qquad .. \qquad .. \qquad (2)$$

The functions $f(\sigma_e)$ and $g(\sigma_e)$ are to be determined by experiment. Now, consider incipient flow under constant stress, starting at $t = 0$. If $g(\sigma_e)$ does not vary too rapidly with σ_e, primary strain at $t = 0$ is

$$\epsilon_{ij}^{(0)} = g(\sigma_e)\,s_{ij} \qquad .. \qquad .. \qquad (3)$$

On the other hand, at constant stress, the asymptotic constant strain rate will be

$$\dot{\epsilon}_{ij} = f(\sigma_e)\,s_{ij} \qquad .. \qquad .. \qquad (4)$$

Forming the corresponding effective strains, from eqs. (3) and (4),

$$\epsilon_e^{(0)} = (2\,\epsilon_{ij}^{(0)\,2}/3)^{1/2} = 2\,\sigma_e\,g(\sigma_e)/3 \qquad .. \qquad (5)$$

$$\dot{\epsilon}_e = 2\,\sigma_e f(\sigma_e)/3 \qquad .. \qquad .. \qquad .. \qquad (6)$$

All experiments to be compared with the above theory have been carried out with different states of plane stress, the principal stresses of which may be $\sigma_1 > \sigma_3 > \sigma_2$, with $\sigma_3 = 0$. If the corresponding principal strains are ϵ_1, $\epsilon_3 = -\epsilon_1 - \epsilon_2$, and ϵ_2, then the Lode variables may be defined as

$$\mu = -\frac{2\,\sigma_2}{\sigma_1 - \sigma_2} - 1 \qquad .. \qquad .. \qquad .. \qquad (7)$$

$$\nu_0 = -\frac{2\,(\epsilon_1^{(0)} + 2\,\epsilon_2^{(0)})}{\epsilon_1^{(0)} - \epsilon_2^{(0)}} - 1 \qquad .. \qquad .. \qquad (8)$$

$$\nu = -\frac{2\,(\dot{\epsilon}_1 + 2\,\dot{\epsilon}_2)}{\dot{\epsilon}_1 - \dot{\epsilon}_2} - 1 \qquad .. \qquad .. \qquad (9)$$

where eq. (8) refers to the principal strains of the tensor $\epsilon_{ij}^{(0)}$ and eq. (9) to the principal strain rates of the tensor $\dot{\epsilon}_{ij}$. From eqs. (3) and (4) may be obtained the relations

$$\mu = \nu_0 \qquad .. \qquad .. \qquad .. \qquad (10)$$

$$\mu = \nu \qquad .. \qquad .. \qquad .. \qquad .. \qquad (11)$$

just as in the v. Mises theory of plastic flow in solid material.

Comparisons were made between eqs. (5), (6), (10), and (11) and all experimental data[5, 6, 7] available to the author, for a number of materials. Figs. 2 and 3 show the experimental verification of these equations in the case of Nimonic 75 at 650° C and magnesium at 50° C, respectively. In both instances, for eqs. (5) and (6), straight lines correspond to the relations $\epsilon_e^{(0)} = k_0\,\sigma_e^{n_0 - 1}$ and $\dot{\epsilon}_e = k\,\sigma_e^{n-1}$ with k_0, n_0, k, n constant. The unit for $\epsilon_e^{(0)} = 10^{-4}$ and for $\dot{\epsilon}_e = 10^{-4}/150$ per hr. In the figures the experimental values have been plotted with rings of a size corresponding to the estimated mean error of observation, in order to give an idea of the accuracy and significance of deviations from theory. Naturally, considerable scatter of the points was found in all cases, but no significant discrepancies could be discovered.

Significant deviations from the predictions of earlier theories of stationary (secondary) creep[1, 4] at large values of total strain have been claimed by Johnson. This may be due to the fact that his creep rates were all determined after a constant time period of $t = 150$ hr. Thus, his experimental determinations of $\dot{\epsilon}$ may have involved different amounts of primary creep for different stress intensities. If primary creep is taken into account, the significant deviations from theory disappear.

Furthermore, examination of the comparisons between eqs. (5), (6), (10), and (11) and the experimental data available, for a number of materials, revealed the following:—As the quantities $\epsilon_e^{(0)}$ and $\dot{\epsilon}_e$, when plotted

against σ_e on a log-log basis, prove to be linear functions within experimental errors, the usual exponential laws with exponents n_0 and n will hold. For magnesium, the exponents decrease with temperature, as might be expected. This rule does not apply with the Hiduminium alloy RR 59, but, on the other hand, the scatter of the experimental points at 150° C for this alloy is unusually large.

Also, without exception, n comes out greater than n_0. This includes the case of a 0·17 per cent C-steel at 455° C, where the determination of n is only very roughly accurate. A closer examination of the phenomenon of relaxation at zero strain shows that a corresponding gradual decrease of stress will occur only if the relation $n > n_0$ holds true.

THEORY II

In cases where primary creep is small and merely constitutes a correction to the total amount of creep strain, the function $g(\sigma_e)$ above could be replaced by a constant for each temperature and stress, irrespective of the amount of strain. Then, an altogether new theory might be propounded:—

$$\frac{d\epsilon_{ij}}{dt} = \begin{cases} f(\sigma_e)\, s_{ij}, & s_{ij}^2 < s^2 \quad .. \\ \varphi\, s_{ij}, & s_{ij}^2 = s^2 \quad .. \end{cases} \quad .. \quad (12a)$$

$$.. \quad (12b)$$

If the flow condition

$$s_{ij}^2 = s^2 \quad .. \quad .. \quad .. \quad (13)$$

where s is a constant, depending on temperature only, is fulfilled, the strain rate according to eq. (12b) is proportional to the stress deviation by a factor φ, just as in the classic v. Mises theory of plasticity. Primary creep will occur only in those regions of a structure, where the flow limit eq. (13) is reached, and there the material will flow indefinitely. Stationary flow with a definite strain rate is maintained in the structure as a whole, owing to the stresses in those parts where the flow limit is not reached. The data given above, and in particular those for carbon steel, indicate that this idealisation is not entirely out of place.

As an application, consider the creep stress distribution in a rotating disc of uniform thickness. For the stationary creep stresses in radial direction σ_r and circumferential direction σ_t, having no regard to primary creep, a method of integration has been given by the author[1, 4]. Alternative methods have been given by Bailey[2] and by Popov[9]. A generalisation of this theory will now be given in adherence to Theory II.

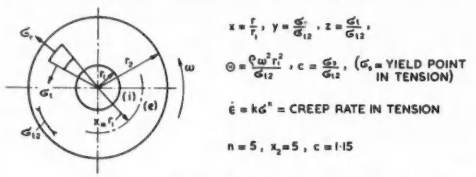


Fig. 4. **Symbols used in calculations relating to rotating disc.**

For simplicity, the treatment will be limited to a disc of constant thickness, occupying the ring domain $r_1 < r < r_2$, with the boundary conditions $\sigma_r(r_1) = 0$, $\sigma_r(r_2) = 0$ (see Fig. 4). Introducing dimensionless variables $r/r_1 = x$, $\sigma_r/\sigma_{t2} = y$, $\sigma_t/\sigma_{t2} = z$, where σ_{t2} is the circumferential stress for $r = r_2$, i.e., for $x = x_2$, two regions $1 < x < x_m$ and $x_m < x < x_2$ are obtained, where the set of eqs. (12b) will hold in the first (inner) region and (12a) in the second (outer) region. Indices i and e are applied to the values of y and z in the inner and outer regions, respectively. The values x_1 and x_2 are the inner and outer boundaries of the disc, and x_m corresponds to the line of separation between the inner and outer regions. Thus, the following integration problem is obtained:—

$$1 < x < x_m \begin{cases} \dfrac{dy_i}{dx} = (z_i - y_i)/x - \Theta x \\ \Delta_i^2 = y_i^2 + z_i^2 - y_i\, z_i = c^2 \end{cases} \quad .. \quad (14)$$

$$x_m < x < x_2 \begin{cases} \dfrac{dy_e}{dx} = (z_e - y_e)/x - \Theta x, \\ \dfrac{dz_e}{dx}\,[1 + (n-1)(2z_e - y_e)^2/4\Delta_e^2] \\ = -3\Theta x/2 - \dfrac{dy_e}{dx}[1 - (n-1) \times \\ (2z_e - y_e)(z_e - 2y_e)/4\Delta_e^2] \\ \Delta_e^2 = y_e^2 + z_e^2 - y_e\, z_e \end{cases} \quad (15)$$

Here, it has been assumed that $\Theta = \rho\omega^2 r_1^2/\sigma_{t2}$, where ρ is the density and ω the angular velocity of the disc. Boundary conditions are $y_i(1) = 0$, $y_i(x_m) = y_e(x_m)$, $z_i(x_m) = z_e(x_m)$, $y_e(x_2) = 0$. For a definition of c, see Fig. 4.

The quantities x_m, σ_{t2}, Θ are *a priori* unknown, and the problem could be termed a non-linear eigen value problem with Θ as a parameter.

A numerical solution of the above problem involved a special procedure, the integrations being carried out by means of a mechanical differential analyser.

It was, however, difficult to obtain a satisfactory accuracy when interpolating between the curves calculated by this differential analyser. An example of such a calculation in the special case $n = 5$, $c = 1{\cdot}15$ $x_2 = 5$, where the values $\Theta = 0{\cdot}10$, $0{\cdot}12$, $0{\cdot}14$, as suggested by previous works[4], were used in the integration, gave $\Theta = 0{\cdot}117$ and $x_m = 2{\cdot}95$. If the older theory[4] is applied to the same problem, eq. (12a) will hold for the entire region $1 < x < 5$, corresponding to the limiting case $x_m = 1$. This gives $\Theta = 0{\cdot}127$ and $c = 1{\cdot}47$.

From the example it could be concluded that a redistribution of stress takes place as a consequence of primary creep. This redistribution is very similar to that found by Hencky[10] in the case when the inner parts of the disc are assumed to follow Hookes law.

Generalisation to real gas turbine discs with non-uniform thickness and temperature will meet no essential difficulty.

BIBLIOGRAPHY

(1) ODQVIST, F. K. G.: Creep Stresses in a Rotating Disc, *IV Internat. Congr. Appl. Mech.*, Cambridge, July 3-9, 1934; Proc., pp. 228-229, 1935.

(2) BAILEY, R. W.: The Utilization of Creep Test Data in Engineering Design, *Inst. Mech. Engrs.*, Proc., pp. 131-349, Nov., 1935.

(3) SÖDERBERG, C. R.: The Interpretation of Creep Tests for Machine Design, *A.S.M.E., Trans.*, Vol. 58, 1936, p. 733.

(4) ODQVIST, F. K. G.: Theory of Creep Under the Action of Combined Stresses with Applications to High Temperature Machinery, *Roy. Swed. Acad. Engn. Res.*, Proc., No. 141, p. 31, 1936.

(5) TAPSELL, H. J. and JOHNSON, A. E.: Creep Under Combined Tension and Torsion, *Engineering*, Vol. 150, 1940, pp. 24-25, 61-63, 104-105, 134, 164-166.

(6) JOHNSON, A. E.: The Creep of a Nominally Isotropic Magnesium Alloy at Normal and Elevated Temperatures Under Complex Stress Systems, *Metallurgia*, Vol. 42, pp. 249-262.

(7) JOHNSON, A. E.: Creep under Complex Stress Systems at Elevated Temperatures, *Inst. Mech. Engrs.*, Proc., Vol. 164, No. 4, pp. 432-447, 1951.

(8) MILLENSON, M. B. and MANSON, S. S.: Determination of Creep Stresses in Gas Turbine Discs Subjected to Plastic Flow and Creep, *N.A.C.A.*, Rep. No. 906, 1948.

(9) POPOV, E. P.: Stresses in Turbine Discs at High Temperatures, *Journ. Frankl. Inst.*, Vol. 243, 1947, pp. 365-389.

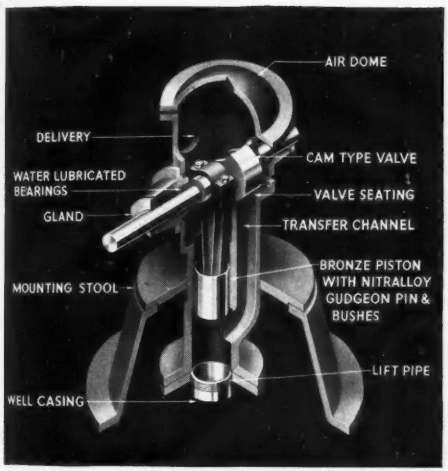
(10) HENCKY, H.: Zur Theorie plastischer Deformationen und die hierdurch im Material hervorgerufenen Nach-Spannungen, *Zeitschr. Angew. Math. Mech.*, Vol. 4, 1924, pp. 323-334.

New Materials, Processes and Equipment

DEEPWELL PUMP

What is claimed to be a new pumping principle is embodied in the Gilgo Deepwell Pump, now in production by Gilbert Gilkes & Gordon Ltd., of Kendal.

The pump, the principal details of which are shown in the illustration, has a mechanically operated delivery valve, which is closed when the piston is moving down and which opens on the upstroke. On the downstroke the piston compresses the water in the lift pipe; as the piston begins to move up, the delivery valve opens, releasing the compressed water. As a result, the whole column of water in the lift pipe jumps upwards, allowing water to flow from the well through the foot valve. At the same time, a similar amount of water is delivered from the pump.



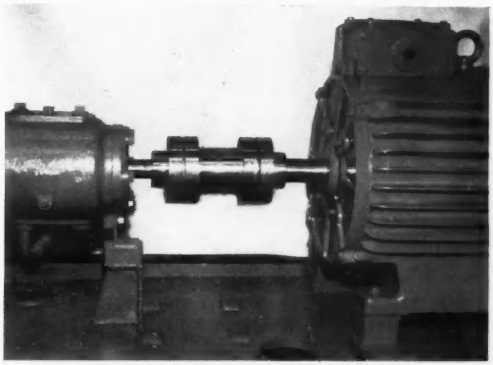
All working parts are on the surface. There are no rods or moving parts in the bore, with the exception of the foot valve, which can, however, be withdrawn easily, without the need for disturbing pipes or for the use of heavy lifting gear. The pump can be driven by an electric motor, or by a petrol, oil, or diesel engine of approximately 2 bhp, *via* a variable-ratio pulley and vee-belt. The maximum lift is 200 ft, with capacities ranging from 60 to 600 gph and a maximum delivery head of 100 ft.

FLEXIBLE METALLIC COUPLINGS

Primarily designed for use in the oil industry, with especial application to the process pump, the "Metastream" Patented Flexible Coupling, a product of Metaducts Ltd., of Brentford, Middlesex, can be used in a wide variety of power transmission applications where conditions of severe misalignment, both angular and lateral, may occur.

These couplings are of all-metal construction, with flexible membranes of stainless steel or Monel metal, and are therefore unaffected by climatic conditions or operating temperatures. By virtue of their design, there is no backlash or play between driving and driven units, and the ample axial flexibility provided is completely independent of torque transmitted.

No lubrication of any kind is required and there are no sliding or rolling members, flexibility being achieved solely through the transmission membranes. These membranes can be removed from the coupling as a unit, without disturbing either the driving or driven members. Transmission units can be replaced in a few



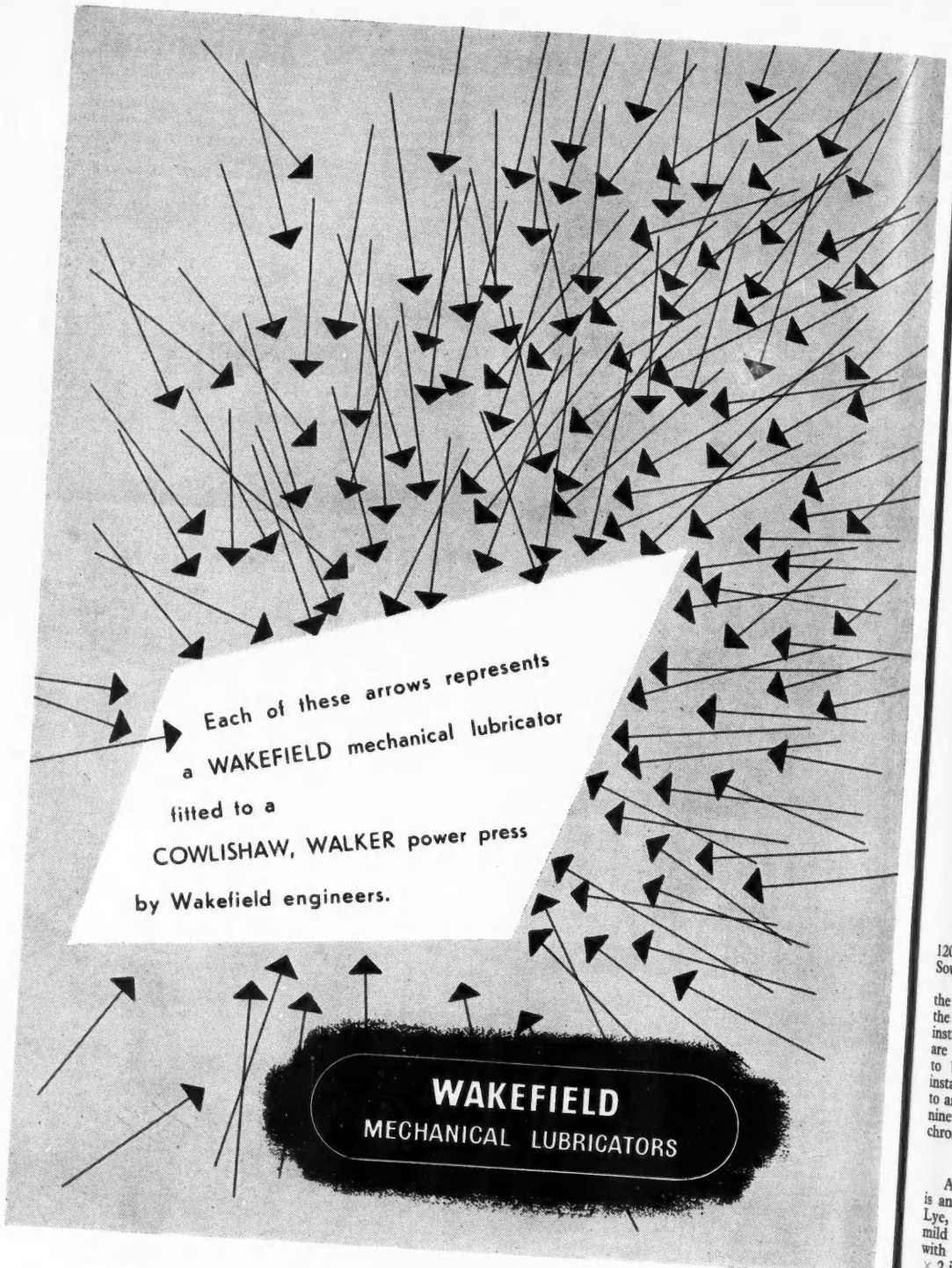
minutes, and there is maximum standardisation and interchangeability of corresponding parts throughout the whole range of couplings, which are made in sizes capable of transmitting up to 2000 hp at 3000 rpm, and which can be supplied in both spacer and non-spacer form, depending on the amount of misalignment likely to be encountered.

The illustration shows a spacer type of coupling fitted to a process pump.

PLATING BARREL

A new addition to the range of plating barrels manufactured by W. Canning & Co. Ltd., of Birmingham, is the "Typhon," which is suitable for depositing the usual metals, with the exception of chromium.

A useful feature of the new barrel is that it may be rotated during emptying to discharge the plated articles. A pneumatic damper ensures a smooth return to the plating position. A welded steel tank, suitably lined for any solution, with a wire mesh tray for holding the


Each of these arrows represents
a WAKEFIELD mechanical lubricator
fitted to a
COWLISHAW, WALKER power press
by Wakefield engineers.
WAKEFIELD
MECHANICAL LUBRICATORS

articles during emptying, can be supplied, if desired.

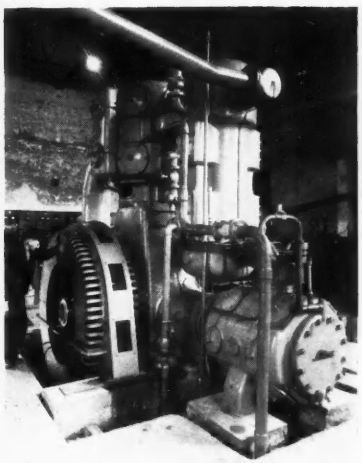
The barrel, which has a built-in motor drive, has an article capacity of from 2 to 3 gal, and a solution capacity of from 9 to 10 gal. The operating space required is 56 in. × 40 in. × 65 in. high.

DIESEL COMPRESSOR

The first diesel compressor with a flywheel-type synchronous motor to be installed in Britain is now running at the Mountain Colliery, South Wales.

With this flywheel-type motor, the rotor is mounted directly on the extended crankshaft of the compressor; thus, no outer bearings are required and no coupling is needed between motor and compressor. As a result, installation and lining-up operations are made much easier than with a normal type of drive, and the whole unit requires considerably less foundation space. This compressor is an AR 9 type of the Atlas Diesel Company, Limited, Wembley.

The stator of the motor is made easily removable, so that all parts of the motor are easily accessible for inspection. The flywheel motors in use with Atlas compressors have been specially designed for this purpose and great care has been taken to ensure vibration-free running. The A.E.G. synchronous motor has an output of 540 hp, and a loading power factor of 0·9 with a full load.



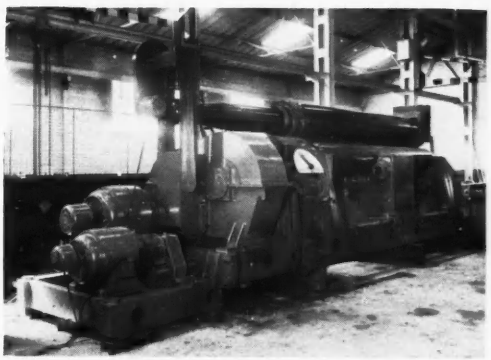
These compressors have a maximum pressure of 120 psi, but, in accordance with standard practice in South Wales collieries, have been regulated to 80 psi.

Ten Atlas AR 9 compressors have been ordered by the National Coal Board. Two are already in use at the Mountain Colliery, near Swansea, another has been installed in a Welsh colliery ready for operation, four are waiting to be installed, and the final three have yet to be delivered. The first compressor, which was installed at the Mountain Colliery, was direct-coupled to an auto-synchronous electric motor. The remaining nine will all be equipped with a flywheel type synchronous motor.

PLATE BENDING MACHINE

A new 3-roll, pyramid-type plate-bending machine is announced by the Bronx Engineering Co. Ltd., of Lye, Worcs. This machine is capable of bending mild steel plates 12 ft in width × 1½ in. in thickness, with alternative capacities of 9 ft × 1¾ in. and 8 ft × 2 in., respectively.

The rolls are machined from solid steel forgings, the diameter of the top roll being 25 in. and that of the bottom rolls 19 in. The bottom rolls have grooves machined in their periphery to assist in gripping the plate. The bottom rolls work in bearings lined with phosphor bronze. The lower part of the housings contains the worm gearing for adjusting the top roll and is provided with covers forming an oil-tight case. The top roll is mounted in bearings of cast steel, lined with phosphor bronze. Both are pivoted to the upper ends of the adjusting screws, to allow the end bearings to be swung down for removing cylinders and also to permit the top roll to be operated in a tilted position for conical rolling. The power to operate the swing-down end bearing is provided by means of a 5-hp motor with its own control gear.



Top-roll adjustment is effected by means of worm gearing located in the main housings, being directly connected to a totally enclosed reduction gear, which in turn is driven from a 40-hp motor. The motor is arranged for reversing by means of hand-operated control gear. To permit the tilting of the top roll, a separate clutch is fitted in the driving shaft, thus disengaging the worm gearing at the extreme end when it is desired to tilt the top roll. An indicator with a large dial is fitted at the operator's position, showing the exact position of both ends of the top roll at any time. Electric limit-switches are also fitted, to cut out the driving motor should the top roll be accidentally overrun, either up or down. An extension is provided on the top roll to counterbalance the weight when swinging down the end bearing. A support is provided at the extreme end of the machine and this engages the ball end of the top roll, operation being effected by means of a 2½-hp motor, seen in the upper part of the illustration, which shows the new machine from the driving end.

MECHANICAL COMPARATOR

A purely mechanical comparator for outside measurements, employing an ingenious system which operates without friction between solids or liquids, is announced by C. E. Johansson Ltd., of Dunstable, Beds. As a result of the system employed, response is instantaneous and without drag, and the whole unit is completely free from wear. This gives the instrument a high degree of sensitivity and ensures repeatability of very fine measurements, making it particularly suitable for the mass checking of precision components to very close limits.

In this instrument, known as the CEJ Mikrokator, the amplifying mechanism between the measuring point and the indicator point is wholly frictionless and entirely free from slackness. The fundamental feature of the Mikrokator is a twisted metal strip of rectangular cross section. Starting from the centre, one half of the strip is twisted towards the right and the other half towards the left. When the twisted strip is stretched, the centre portion to which the pointer is secured rotates

LEY'S

For strength and machinability

Where strength and rigidity are important, Ley's malleable castings are being used very extensively. The illustrations show a four-pinion differential cage, for a tractor, made in 'Lepaz'.

LEY'S 'BLACK HEART' MALLEABLE CASTINGS:		LEY'S 'LEPAZ' PEARLITIC MALLEABLE CASTINGS:	
Elongation:	18%	Elongation:	6%
Yield Point:	16 tons p.s.i.	Yield Point:	21 tons p.s.i.
Tensile Strength:	24 tons p.s.i.	Tensile Strength:	38 tons p.s.i.

LEY'S MALLEABLE CASTINGS COMPANY LTD., DERBY. TELEPHONE: DERBY 45671

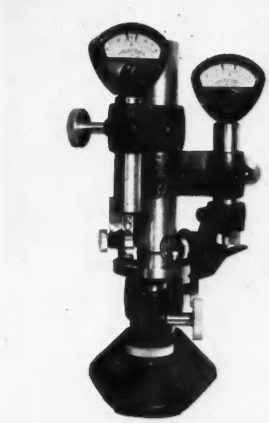
EUROPE'S LARGEST MALLEABLE PRODUCERS

We offer the full collaboration of our engineers

LEY'S

about an axis through the centre line of the strip. One end of the strip is free to stretch, this movement being directly actuated by the measuring point of the instrument.

In an amplification mechanism of this type, it is of the greatest importance that the indicator pointer should be as light as possible, so that the twisted strip can better withstand shocks and vibrations. A very efficient damping effect is provided by allowing the strip to rotate in a drop of oil, which is held in a short length of split tubing positioned close to the indicator pointer; and this brings the pointer very quickly to rest. The pointer used in the Mikrokator is made of tapered glass tubing and, so that it may be easily seen, it is provided with a tip of duralumin.



Using a Mikrokator strip, suitable leverage, and a glass indicator pointer, a stable amplification of 200,000 times and more may be obtained. For a higher amplification, or a smaller force for a certain reading, a mirror and light beam indicator may be used. With a light beam indicator, 35 in. in length, it is possible to attain stable amplifications of 12,000,000 : 1, and higher.

A complete series of Mikrokator instruments is manufactured, the least sensitive having a measuring range of $\pm$ 0·003 in. and graduations for every 0·0001in., the most sensitive having a range of $\pm$ 0·0001 in. with graduations for each 0·000002 in. Special Mikrokators have been manufactured with a measuring range of $\pm$ 0·00002 in. and graduations for each 0·000001 in. The measuring pressure of the standard Mikrokator is approximately 250 grams, but instruments having a specified measuring pressure, or an adjustable measuring pressure from 50 to 1000 grams, are made on request.

Mikrokators are provided with two tolerance pointers, which can be adjusted at the back of the instrument. To prevent eye strain, the dial graduations are black on a yellow background, and the indicator pointer and tolerance pointers are also black.

RELAY FOR AUTOMATIC CONTROL OF REACTIVE kVA

Reliable power-factor improvement can now be obtained quite automatically by using a new relay developed especially for this work by Chamberlain & Hookham Ltd., of Birmingham, a subsidiary of The General Electric Co. Ltd. The relay is intended for use with static condensers of appropriate capacity which will draw a leading reactive current and thus neutralise the lagging reactive current of the load; sections of the condensers are automatically switched in or out, as required, to meet the needs of varying load conditions. The relay is suitable for all types of installation, and is much smaller and more compact than equipment previously available.

The relay consists of two interdependent parts, an induction pattern mechanism sensitive to reactive volt-amperes, and a switching unit, driven by a reversible motor, respectively. The reactive volt-ampere element operates on the same principle as the induction watt-hour meter and consists essentially of two electromagnets, between which a pivoted aluminium disc is free to rotate. The current and voltage coils are connected into the load circuit in such a manner that, assuming balanced load and unity power-factor, the voltage applied to the voltage electromagnet is lagging 90 deg. behind the current flowing through the current coil. Under these conditions no torque is developed on the disc and it remains stationary under the influence of a hairspring.

The switching unit motor is also constructed on the same lines as an induction watt-hour meter, having two electromagnets, between which a pivoted copper disc is free to rotate. The voltage winding is centre-lapped, this connection going to one side of the voltage supply. The coil receives its energisation *via* adjustable contacts on the reactive volt-ampere element. The second electromagnet on this motor is energised from a secondary winding on the voltage electromagnet of the reactive volt-ampere element and remains permanently energised.

The reversible motor is connected *via* a train of gears to a contact-making device, which progressively closes or opens a series of circuits, depending upon the direction of rotation. These heavy duty contacts (up to ten in number) can be used to operate contactors for altering the number of power-factor correction condensers connected to the load circuit.

The two elements of the relay may be mounted side by side in a horizontal case or one above the other in a vertical case, as shown in the illustration. In each instance, the interconnections between the two elements are carried through small terminal blocks mounted on the base, so that one element can be easily removed without disturbing the other, should the need arise. Projecting and flush pattern cases are available for both the horizontal and the vertical layout.

Here we go round the Standard Bush...

We are reckoned to be one of the leading suppliers of plain bearings and bushes in the country, and indeed in the world. We mention this in passing. Now, about the STANDARD idea... Whether you produce on a very large scale or a modest one you must benefit from the use of standard components. Take bronze bushes. If you have these specially made to your own sizes you incur costs for drawings, patterns, tools, etc. and take up time in a way that may well be unnecessary. Unnecessary because Glacier make Standard bushes in ranges sufficiently wide to cover all your probable requirements. Our Standard range of Bronze Bushes alone has 191 variations in perfect series, graduating in length, in nominal bore, in nominal housing size — plus five standard grooving designs. You order your bushes from stock for immediate delivery, without restriction as to quantity. We supply them, finished and ready in Glacier bronze, with an allowance in the bore for final sizing after assembly. *Whether it's bronze bushes, wrapped bushes or bronze bars* . . . **THAT'S THE LOGIC BEHIND—**

GLACIER REGD. TRADE MARK **Standard sizes**

THE GLACIER METAL COMPANY LIMITED, ALPERTON, WEMBLEY, MIDDLESEX

HIGH-PRESSURE INDUSTRIAL COMPRESSOR

Designed originally to stringent Ministry specifications, a compact single-cylinder, high-pressure air compressor unit, suitable for a wide range of industrial duties, is now generally available from The Hymatic Engineering Co. Ltd., of Redditch, Worcs. Known as the Hymatic SH20/AS, it will deliver over 4 cfm of free air at pressures of up to 350 psi at 750 rpm—a performance more than sufficient for the pneumatic starting of smaller diesel engines, the operation of air blast switchgear, the charging of high pressure air control systems, etc. When the need arises, working pressures can be raised to a maximum of 500-600 psi for special applications.

The stepped piston, operating in the two-stage 200 cc-capacity cylinder, embodies the inter-stage transfer valve, so that the ability to deliver at high pressures is combined with compactness and simplicity.

Splash-type lubrication from the sump is employed and cooling is normally effected by a combined fan and pulley. Power absorption when the unit is delivering its full capacity against a working pressure of 350 psi is 2·5 hp at 750 rpm.

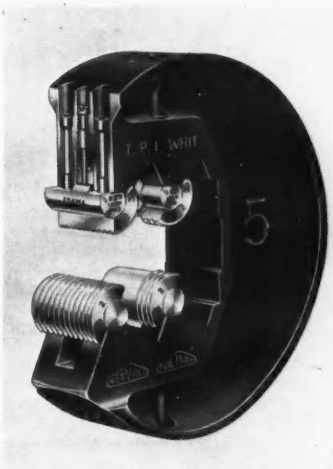
Measuring 21 in. × 11¼ in. × 8 $\frac{5}{16}$ in. overall, the compressor weighs 28 lb complete with air filter.

THREAD CALIPER GAUGES

The Newall adjustable roller caliper gauge for the inspection of threads on male components has been superseded by the Newall-Tolimit thread caliper gauge developed by Tolimit Gauges Ltd., of London. This gauge uses anvils of cylindrical form, carrying a thread of the same pitch as the component to be inspected, but of opposite helix. Each anvil has three positions to which it can be indexed, allowing a fresh gauging face to be presented as wear takes place, as shown in the accompanying sectionalised illustration. The anvils are carried on pins of substantial diameter, which are firmly fastened at each end of the gauge frame, to prevent "spring" during use.

For the inspection of components of a smaller diameter than it is possible to manufacture the anvils, anvils are produced to a predetermined size, on which a multi-start thread, the helix angle of which accurately conforms to the helix angle of the workpiece, is ground.

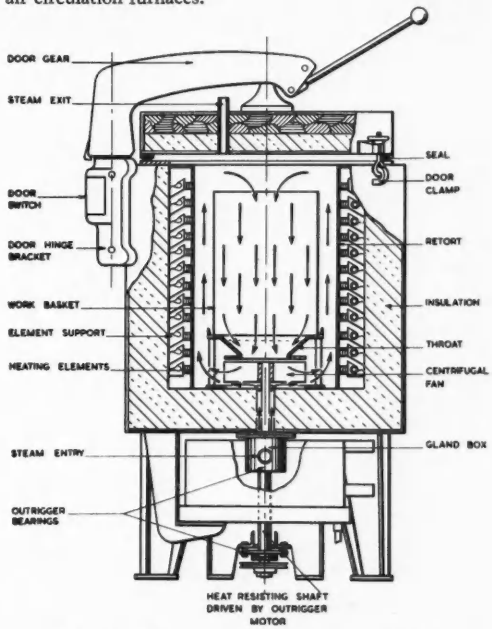
When manufacturing a caliper gauge of large dimensions it is, of course, impossible to use anvils of the same diameter as the workpiece, and in these cases the anvils are ground with either helical or annular grooves to give the least helical interference. Dirt grooves, which eliminate interference, are ground in the anvils. The



gap of each frame is produced to accurate limits and various classes of fit are obtained by interchangeable anvil pins, one "go" and one "no-go." If a gauge is set to a close fit and it is necessary to change it to a medium or free fit, standard pins can be supplied for the user to make the alterations by substituting the pins.

STEAM TEMPERING FURNACE

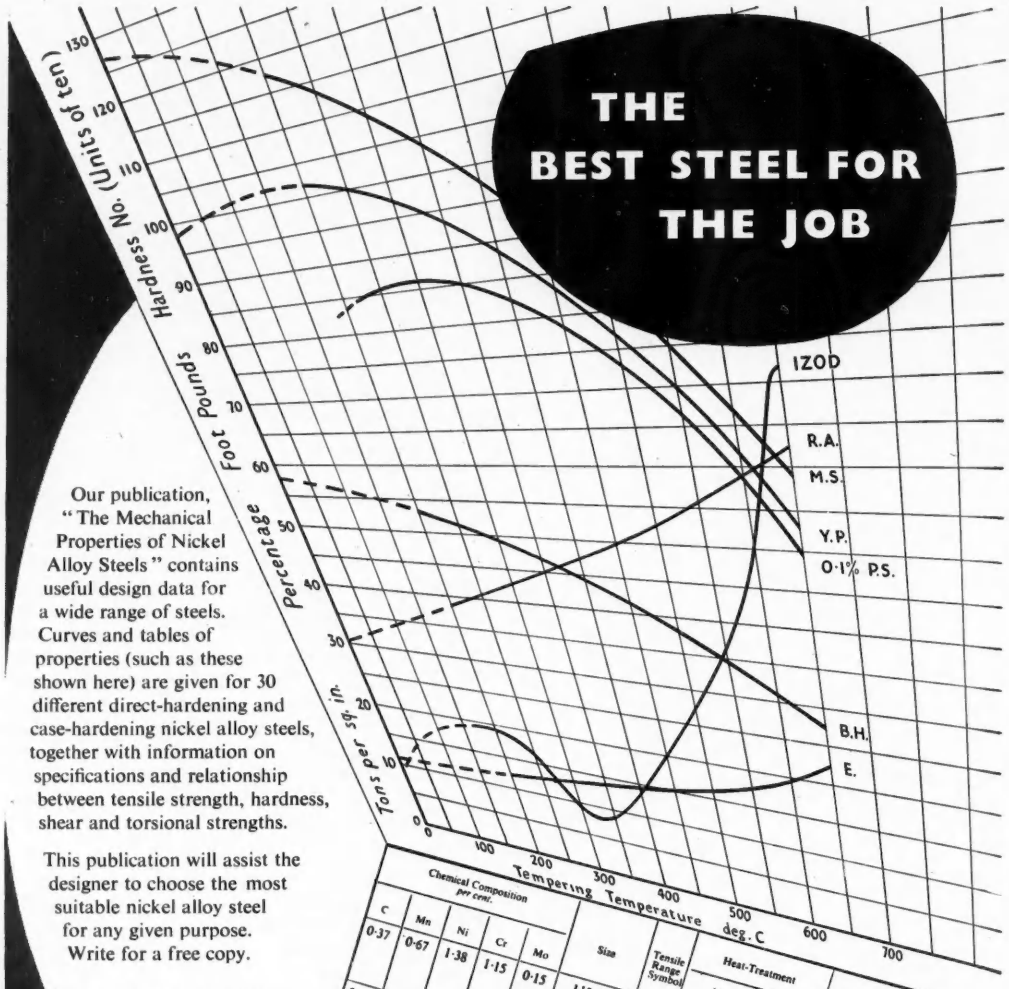
Details of the new equipment designed specifically for steam tempering by Wild-Barfield Electric Furnaces, Ltd., of Watford, Herts., show that the new furnace follows closely their already well-known vertical forced air circulation furnaces.



The design, however, allows for many conditions not normally vital in a forced air circulation furnace. The chamber contains a retort for sealing off the effective

(*Concluded on page* 486)

THE BEST STEEL FOR THE JOB



Our publication, "The Mechanical Properties of Nickel Alloy Steels" contains useful design data for a wide range of steels. Curves and tables of properties (such as these shown here) are given for 30 different direct-hardening and case-hardening nickel alloy steels, together with information on specifications and relationship between tensile strength, hardness, shear and torsional strengths.

This publication will assist the designer to choose the most suitable nickel alloy steel for any given purpose. Write for a free copy.

Tempering curves and table showing the properties obtainable with different heat-treatments and ruling sections for a low nickel-chromium-molybdenum steel to Specification En 110.

Chemical Composition per cent.					Size	Tensile Range Symbol	Heat-Treatment		Mechanical Tests			
C	Mn	Ni	Cr	Mo			Harden °C.	Temper °C.	Y.P. t.s.i.	M.S. t.s.i.	Elong. per cent	Izod ft.-lb.
0·37	0·67	1·38	1·15	0·15	1¼" dia. 1½" dia. 1¾" dia. 1¼" dia.	W V U T	O.Q.840 " " "	560 590 620 650	70·3 65·2 58·8 52·8	74·3 69·8 66·3 60·2	17 20·5 21 23·5	35 56 64 70
0·37	0·67	1·38	1·15	0·15	2¼" sq. 2½" sq. 2¾" sq. 2¼" sq.	W V U T	O.Q.840 " " "	560 590 620 650	65·1 61·5 55·4 50·1	71·5 68 64 58·2	19 21 20 23·5	44 63 71 88
0·37	0·67	1·38	1·15	0·15	4" sq. 4" sq. 4" sq. 4" sq.	V U T S	O.Q.840 " " "	560 590 620 650	61·7 55 51·5 48·6	68·8 62·9 60·2 56·8	19 20 21 24	32 65 74 85
0·37	0·67	1·38	1·15	0·15	6" sq. 6" sq. 6" sq. 6" sq.	V U T S	O.Q.840 " " "	560 590 620 650	62·0 56·2 50·6 45·7	68·0 63·4 58·5 56·4	15·5 17·5 19·5 21·5	19 44

THE MOND NICKEL COMPANY LIMITED · SUNDERLAND HOUSE · CURZON STREET · LONDON · W1

12/SL/38

CLASSIFIED ABSTRACTS

Numerous important abstracts which, for lack of space, cannot be published in our main editorial columns, are regularly included in condensed form in this section. Subscribers may obtain photostat copies of all original articles at cost.

BOILERS

Experiences During the Last Ten Years in the Design of Marine Boilers.

By R. L. J. HAYDEN. (From a paper presented at a meeting of the *North-East Coast Institution of Engineers and Shipbuilders, Newcastle-upon-Tyne*, November 27, 1953, pp. 152-192, 39 illustrations.)

THE design of marine oil-fired water-tube boilers has made significant advances in the last ten years. To meet the demand for more efficient machinery, pressures in common use have increased from 450 psi to 650 psi, while 850 psi is by no means unusual. Similarly, steam temperatures have been raised from 750° F to 850° F, and in some instances to 950° F. High-pressure water-tube boilers have become normal practice in fast cargo liners and tankers.

This paper describes the progress made in marine boiler design during the past ten years and gives examples of the different types of boiler designed to suit different classes of vessel. Operating experiences with each part of the generating unit, such as furnace, boiler, superheater, economiser, and air-heater, are described. A survey of the troubles encountered with each of these components is indicated and it is shown how the designs have been modified to overcome the difficulties.

Some indications of the probable trend of future development is given. In this connection, it is certain that steam temperatures will rise, until 950° F is common practice. The use of even higher steam temperatures will await experience with land installations using 1000° F and 1050° F, and will depend on the attitude of inspecting authorities to steam-pipe survey and all-welded steam-pipe systems. It would appear that fewer boilers, each of large capacity, will be fitted in vessels of high horse-power, so as to reduce the length of boiler rooms. The practical limit appears to have been reached with regard to the effectiveness of heat recovery equipment, such as economisers and gas air-heaters. Vital areas of exposed brickwork should be constructed in better quality bricks, while permanent fittings should be designed to facilitate boiler cleaning by water washing. Boiler linings should be able to withstand wetting, and proper drainage for wash water should be provided. Finally, the effective grouping of instruments and controls, and marrying with turbine instruments and controls, will undoubtedly make boilers easier to operate, especially in smaller ships.

ELECTRICITY AND MAGNETISM

The Internal Friction of Ferromagnetic Substances.

By N. KUNITOMI. (From *The Science Reports of the Research Institutes, Tohoku University, Japan*, Series A, Vol. 5, No. 4, August, 1953, pp. 287-310, 17 illustrations.)

IN ferromagnetic substances, the origin of internal friction under low stress amplitude has been considered to be due to two kinds of eddy currents. The first of these, known as the macroscopic eddy current, has been studied by Brown and its theoretically predicted contribution to internal friction is known to be consistent with experimental data. The second eddy current, however, known as the microscopic eddy current, has not as yet been investigated, except in the demagnetised state.

In this paper, the microscopic eddy current has been calculated theoretically as a function of the magnetisation, and the results have been compared with experimental data obtained with substances having negligibly small anisotropic energy. Two different theories have been developed under two assumptions on the generating mechanism of microscopic eddy current. The first theory, which assumes that the microscopic eddy current is induced by the rotation of the spontaneous magnetisation, concludes that the relation between internal friction and the magnetisation is given by a curve with a maximum starting from a finite value at demagnetised state. The second theory assumes that there is a displacement of the 180 deg. domain boundary and concludes that internal friction is proportional to the square of the magnetisation.

To confirm these theories, three series of measurements of internal friction were made, using transversal vibrations of about 500 to 1000 cps, as follows :—(1) The effect of superlattice formation on the internal friction of Ni_3Fe was observed, and the results were explained satisfactorily by considering both macro- and microscopic eddy currents. In this case, microscopic eddy current is considered to be induced by the rotation of the spontaneous magnetisation. (2) Internal friction of field-cooled Ni_3Fe was also explained by the microscopic eddy current due to the rotation of the spontaneous magnetisation. (3) The behaviour of the internal friction of 65-Permalloy shows a remarkable difference from that of Ni_3Fe. This could not be explained either by considering the rotation of the spontaneous magnetisation or by considering the displacement of 180 deg. domain boundaries. The internal friction of Perminvar shows an intermediate character between Ni_3Fe and 65-Permalloy.

ELECTRONICS

Theoretical Resistivity and Hall Coefficient of Impure Germanium Near Room Temperature.

By P. G. HERKART and J. KURSHAN. (From *RCA Review, U.S.A.*, Vol. 14, No. 3, September, 1953, pp. 427-440, 9 illustrations.)

THE resistivity of high-quality single-crystal germanium is determined by its impurity content and, in turn, resistivity can be used as a measure of purity. The engineer using semi-conductor devices will find it most convenient to specify germanium purity in electrical terms by its conductivity type (*n* or *p*) and its resistivity at some standard temperature, such as 25° C. In this paper, the temperature variation of resistivity over the range—100° C to + 140° C has been calculated and plotted for both *n*-type and *p*-type germanium with different impurity content, ranging from 0·1 ohm-centimetre to 60 ohm-centimetres at 25° C.

When germanium is first purified and then intentionally doped with a single impurity, it is desirable to know the relationship between actual impurity content and resistivity or Hall coefficient. Ordinarily, with reasonably perfect crystals, resistivity can be used to specify impurity ; on the other hand, for highly doped material, or if crystal perfection is uncertain, the Hall coefficient is a more reliable index. These relationships have been calculated for 25° C and are plotted, again for both *n*-type and *p*-types. The curves can be used either to predict electrical values from known impurity

THEY SAID IT COULD NOT BE DONE . . .

BUT WE DID IT . . . AND CUT COSTS BY 25%

When we set out to produce thermo-plastic mouldings at the rate of 2,400 per hour from a single die, all fully trimmed and absolutely accurate — we were told we were attempting the impossible. But we did it, having developed a special machine to cope with the work, and are now in a position to undertake further work in spite of large demands. Here are the facts :—

(1) Single dies (30 to 40 shots per minute) cut die costs by up to 87½% compared with 20 impression die costs, speed up tooling, ensure absolute uniformity in output and highest possible accuracy.
(2) Metal inserts moulded simultaneously synchronous two colour work possible.
(3) Components of unusual complexity in shape can be produced.
(4) Up to 560,000 mouldings produced from 1 lb. material.
(5) Minimum quantity accepted 100,000. Maximum weight, 1 dram. Maximum dimension 1¼ in.
(6) Full technical and advisory service available.
(7) We specialise in NYLON Mouldings.

FACTS *Providing the minimum quantity is ordered we guarantee cheaper, faster delivery than otherwise available. Write for samples and literature. Kindly send details or drawings of the component you are interested in and ask for samples of typical mouldings.*

GEORGE Goodman LIMITED
Specialists in NYLON AND THERMO-PLASTICS

ESTABLISHED 1810

ROBIN HOOD LANE, HALL GREEN, BIRMINGHAM, 28. Tel.: SHIRLEY 2237

content, or to interpret measured electrical values in terms of germanium analysis.

A useful rule of thumb, applying between 20 ohm-centimetres and 0·1 ohm-centimetre at 25° C (the resistivity range useful for transistors), gives the inverse proportionality between impurity content and resistivity ρ in ohm-centimetres, as follows :—

$$\text{mol-fraction of impurity} = \frac{3{\cdot}8 \times 10^{-8}}{\rho} \text{ (for } n\text{-type germanium)}$$

$$\text{mol-fraction of impurity} = \frac{8{\cdot}1 \times 10^{-8}}{\rho} \text{ (for } p\text{-type germanium)}$$

FLOW MECHANICS

Fundamental Laws of Fluid Mechanics in Tensor Representation and Application to the Theory of Turbomachines.

By L. S. Dzung. (From *The Brown Boveri Review, Switzerland*, Vol. 40, No. 8, August, 1953, pp. 321-330, 4 illustrations.)

The general equations of aerodynamics and thermodynamics are the starting point for the advanced investigation of many problems in fluid mechanics. Since its modest beginning with Euler's one-dimensional turbine equation, this theory has been developed to such a stage that three-dimensional problems are becoming the centre of interest in modern research.

This paper derives the basic equations in the most general forms and attempts to clarify some points in certain relationships. A short account of tensor analysis is given and the concepts needed in its application are explained. The principle advantage of tensor notation applied to the field of technical fluid mechanics is that it can be adapted to the mathematical ability of the individual reader. An engineer, capable of working with differential calculus, will be able to interpret the equations correctly without any knowledge of tensor analysis. Indeed, owing to the fact that tensor analysis is used in relativity theory and on account of the insistence of those who would like to see it employed in all branches of science, the average engineer is inclined to fight shy of what is usually considered a ponderous tool.

FLOW OF FLUIDS

Design of and Development Tests on the Sfindex Annular Jet Nozzle and Turbine.

By H. U. Widmer. (From *Technische Rundschau, Switzerland*, No. 29, July 17, 1953, pp. 9-11, 14 illustrations.)

In *Technische Rundschau*, No. 25, June 19, 1953, a patent review publicised a new type of guide-mechanism for producing swirling flow, under the title of " The Sfindex Annular Flow Turbine." Later, P. U. Weber, in the technical section of *Neue Zürcher Zeitung*, June 24, 1953, discussed the basic principles of the new mechanism and made special reference to possible applications.

In the above fundamental considerations, it is stated that many hydraulic machines and fluid devices require the existence of rotationally symmetrical swirling flow, transforming a swirling flow into a parallel flow, or converting a swirl of a given magnitude into another. It is also pointed out that, in addition to uniform distribution and control of flow angle, efficiency is of great importance in turbo-machine applications.

In this article, H. U. Widmer gives a theoretical and technical discussion on the Sfindex annular jet nozzle and turbine, together with detailed accounts of design and development tests. After discussing the theoretical considerations of the flow pattern of the nozzle, he describes the salient features of an experimental test nozzle and the experimental determination of its efficiency. Estimates show that the maximum total error in the efficiencies measured can amount to ± 4 per cent, though the effective error is certainly less.

He then describes a model test installation for a full admission impulse turbine, discusses test results, and predicts the performance of a full-scale turbine from the efficiency curve obtained with the model.

From the results obtained, it would appear that model tests on the Sfindex annular flow nozzle and the annular flow turbine have, for the most part, confirmed all expectations. It has been proved experimentally that the angle of the swirling flow from such a nozzle remains practically constant and, over the entire range of control, high efficiency is obtained. Also, the present test results on a model turbine would tend to demonstrate the advisability of considering the application of the design to full-size machines.

GAS TURBINES

Fuel Systems and Controls for Marine Gas Turbines.

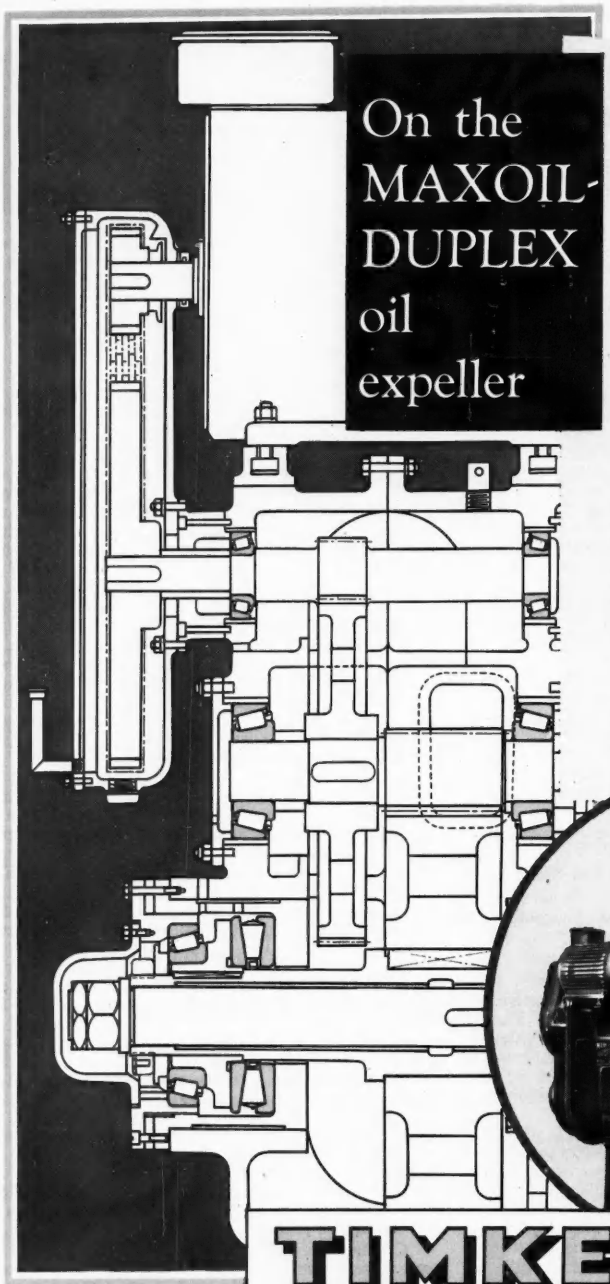
By R. F. Darling. (From a paper presented at a meeting of the *Institution of Mechanical Engineers, London*, November 27, 1953. 19 pages, 27 illustrations.)

As reliability is the first requirement in a marine power plant, the necessity for a reliable system of controls cannot be over-emphasised. Indeed, it is the control system, perhaps more than anything else, which can make or mar an engine from the operational point of view, so much so that the usual considerations of cost, space, weight, etc. become relatively unimportant.

In its narrowest sense, the word " controls " may be taken to denote little more than the fuel system, but, in a wider context, such topics as the number and type of combustion chambers, the transmission and means of reversing, the igniter, and the starting drill are all relevant. In this paper, a description of the control system of an existing unit is given, together with the reasons why various features were adopted in the first place, and the characteristics of the system, both good and bad, which have been revealed on the test bed. The paper is not, however, concerned only with this one engine, an attempt being made rather to discuss the whole subject by reference to a typical example.

The sprayers, control blocks, fuel system, transmission, reversing mechanism, and governors are described in turn. Probable future developments are considered, but these are found to depend mainly on the way in which the gas turbine itself is developed for marine purposes. The paper therefore concludes with a discussion of the type of gas turbine most likely to be installed in merchant vessels, and the means whereby it will be controlled. In this connection, it would appear that the double compound type of engine, with free, intermediate-pressure power turbine may be expected to command a ready market in many classes of vessel. The use of blade cooling should enable gas temperatures of at least 1500° F to be employed, and this will lead to a corresponding increase to 12/1, or perhaps considerably more, in compression ratios. Turbines will be designed to withstand rapid fluctuations in temperature. Intercooling between compressors will be a universal feature, and heat exchangers will be utilised in most instances, though reheat will not usually be employed.

Combustion will probably be carried out in from two to six chambers, mounted in parallel. Sprayers will be highly accessible, and there will be provision for withdrawing them while the engine is running. The position regarding transmission and reversing is by no means clear, but epicyclic gearboxes and hydraulic couplings are the two most likely possibilities. The arrangement of components will be chosen so as to give



On the MAXOIL-DUPLEX oil expeller

This interesting machine, shown by courtesy of the makers, Rose, Downs and Thompson Limited, of Hull, is used for expelling oil from all kinds of seeds, and is supplied to many parts of the world.

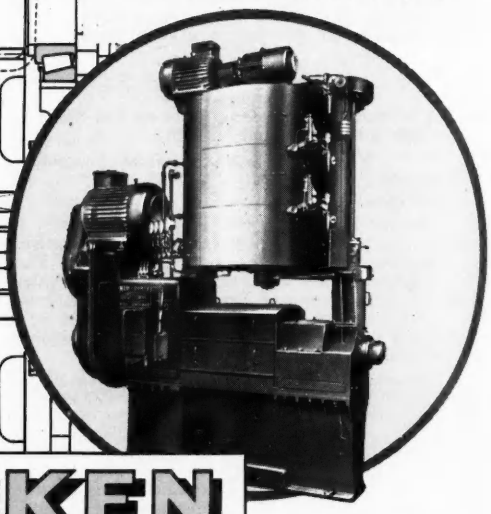
The sectional drawing shows some of the construction, and the way in which the Timken tapered-roller bearings are installed.

The Timken tapered-roller thrust bearing takes the heavy thrust from the main screw of the press.

BRITISH TIMKEN LTD.
Duston, Northampton;
and Birmingham

Telephone: Northampton 4921/8
Telegrams: Britimken Phone Northampton

Subsidiary Companies: Fischer Bearings Company Ltd., Wolverhampton. Timken-Fischer Stockists Ltd., Birmingham.



TIMKEN

REGD. TRADE MARK: TIMKEN

MADE IN ENGLAND

tapered-roller bearings

simplicity and accessibility rather than compactness. The power plant will be controlled from zero to maximum by the fuel lever alone, and response should be extremely rapid and sensitive. The only other control will be that of the means for reversing.

HYDROELECTRIC POWER PLANTS

Present Trends in Surge Tank Design.

By C. JAEGER. (From a paper presented at a meeting of the *Institution of Mechanical Engineers, London*, November 6, 1953. 15 pages, 17 illustrations.)

SURGE tanks are usually associated with conventional hydroelectric power developments incorporating surface power houses. In recent years many underground power stations have been built and these, too, require surge tanks, sometimes giving rise to new and difficult hydrodynamic problems of their own.

The aim of this paper is not to reproduce the well-known elementary theory of surge tanks, but rather to disclose some modern research, where the surge tank is considered as a most important element in the chain of mechanisms for obtaining a rapid and simple adjustment of the load. To this end, the theory of surges in surge tanks is summarised and some preliminary remarks on the stability of surges are introduced. Descriptions are given of the different types of surge tanks, with special mention of surge tanks in conjunction with underground power stations.

The loading conditions to be adopted are discussed and the reason why load changes on the electrical grid are the prime cause of surges is explained. The basic calculations by Italian, Swiss, French, and British engineers are reviewed, and it is shown that, despite many apparent disparities on special points, there is widespread agreement on fundamental questions. The interaction of surges, water hammer, and turbine governing is discussed in the light of the most recent tests on large power stations and of the results of modern theories, and the importance of the influence of water hammer on surge tank design is considered, together with the special case of surge tanks connected to feeder canals.

ILLUMINATING ENGINEERING

A Survey of Vehicle Headlights.

By V. J. JEHU. (From *Transactions of the Illuminating Engineering Society, Great Britain*, Vol. 18, No. 9, 1953, pp. 249-259, 3 illustrations.)

OBSERVATIONS have shown that much of the dazzle experienced on our roads at night is caused by the great differences which exist between the lights on different vehicles. These differences arise in various ways: The lamps themselves are of many different designs, many have deteriorated considerably since they were first fitted, some are out of focus, some are not aimed with a sufficient degree of accuracy, and the vehicles on which they are mounted alter their tilt with every change of loading.

To obtain information about the extent of some of these differences, measurements of aim and beam intensity have been made on the headlamps and passlamps of a sample of cars and commercial vehicles chosen at random from the traffic on one of our main roads. The measurements, which were made with a commercial beam setter specially modified to facilitate this kind of testing, were effected in daylight on a concrete lay-by on the A40 road; about 400 cars and 400 commercial vehicles were examined.

The survey showed considerable variations in both the horizontal and the vertical aiming of the lamps, the standard deviations being approximately 2 deg. for the driving beams and 2½ deg. for the meeting beams from single-beam lamps. Furthermore, whilst the proportion of the driving beams aimed within ± ½ deg., of a specified correct aim, either in the vertical or in the horizontal direction, was about 30 per cent for the lamps on cars and 20 per cent for the lamps on commercial vehicles, only 9 per cent of the beams on cars and 5 per cent of those on commercial vehicles were aimed within these limits in both the vertical and the horizontal directions.

The aim of flush-fitting headlamps was much better than that of other types of lamp. Almost 13 per cent of the driving beams were so diffuse, because of deterioration or defocusing, that no estimate of aim could be made, whilst about 6 per cent of the lamps did not work. Measurements of the intensity in the horizontal plane of the meeting beams showed that (a) the proportion having a high-horizontal intensity, i.e., the proportion likely to cause dazzle, was greater for single-beam than for double-beam headlamps, and for passlamps on cars than for passlamps on commercial vehicles, and (b) flush-fitting lamps were, on the average, superior to other types of lamp in that few of them gave either a very low or a high horizontal intensity, implying that they provided better direct vision and less tendency to cause dazzle.

The maximum intensity of about 10 per cent of the meeting beams from individual headlamps was less than 1000 cd, indicating that a very considerable deterioration had occurred. About 40 per cent of driving beams had horizontal forward intensities of less than 5000 cd. The commoner faults in headlamps were improper focusing or fitting of bulbs, failure of dipping systems, and reflectors in poor condition.

These results clearly indicate that the standard of aiming of headlamps and passlamps is very poor, and that many lamps do not provide an adequate driving light.

IRON AND STEEL

Comparative High-Temperature Properties of British and American Steels.

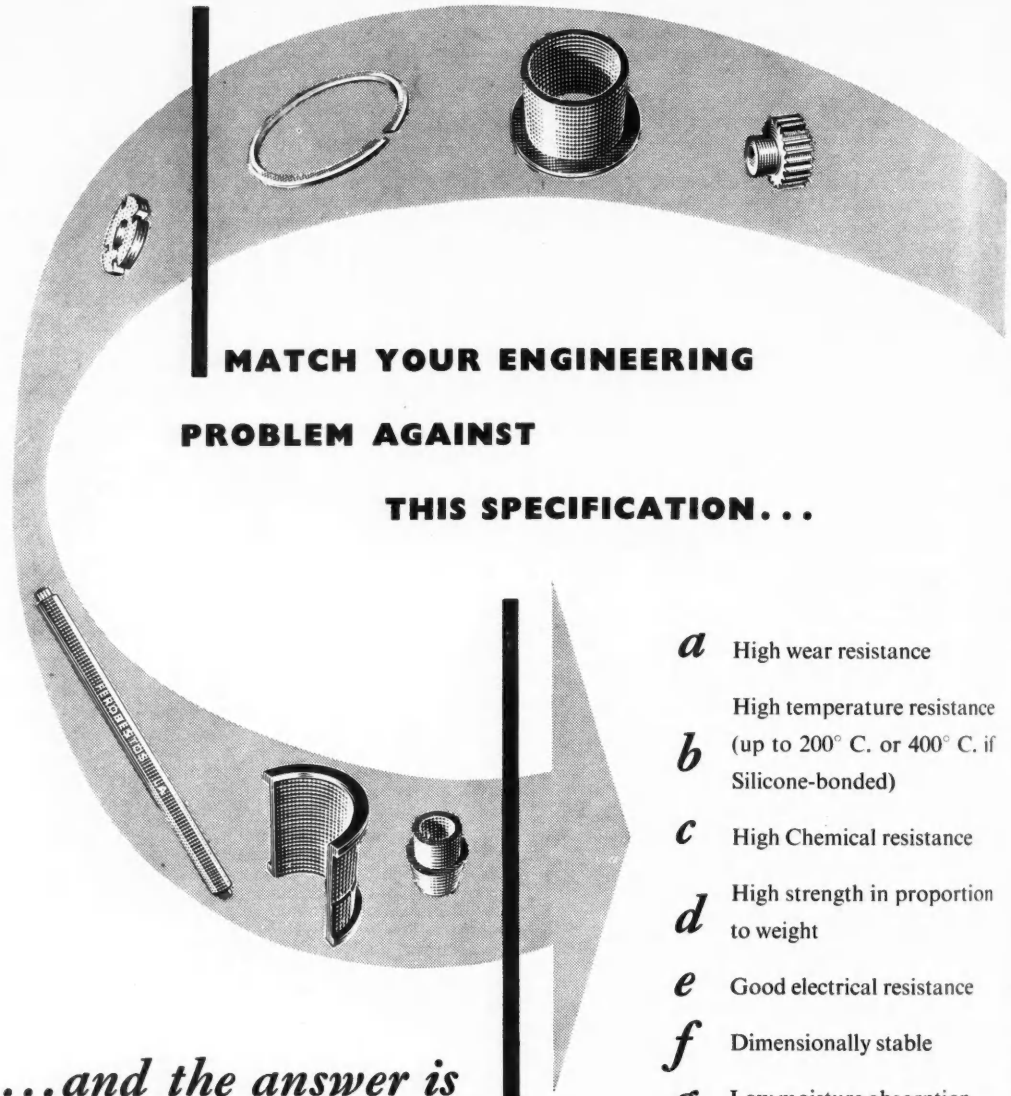
By W. E. BARDGETT and C. L. CLARK. (From a paper presented at a meeting of the *Institution of Mechanical Engineers, London*, December 4, 1953. 8 pages, 12 illustrations.)

SEVERAL quite substantial differences are found in creep data on similar steels published in various countries. In view of the importance of these differences in relation to design stresses, arrangements were made for an exchange of specimens between Great Britain and America, to determine whether laboratory test results, from the same steel, would be in agreement, and to compare the creep resistance of selected steels.

Five representative high-temperature steels were chosen, comprising three commonly used ferritic steels and two austenitic steels. For each composition, four creep curves were obtained, two by each laboratory. Stress, time, and temperature adopted in the tests of both laboratories were the same, and no attempt was made to standardise test procedure.

A high degree of reproducibility was shown by the test results from both laboratories on the ferritic steels, but those on the austenitic steels showed generally substantial differences. This is attributed to the greater sensitivity of austenitic steels to variations in heating period, prior to testing, and in rate of loading. In any laboratory, these conditions must be closely controlled, in the case of austenitic steels, in order to obtain reproducibility.

On the basis of the limited tests described, it would appear clear that, for certain of the steels examined, there is no justification for differences in stress specifications in the two countries. The major differences, found in the austenitic steels, are probably explained on the basis of composition and grain structure, but additional work seems desirable, in order to study these factors for the purpose of achieving the highest standard of creep resistance.



MATCH YOUR ENGINEERING PROBLEM AGAINST THIS SPECIFICATION...

a High wear resistance

b High temperature resistance (up to 200° C. or 400° C. if Silicone-bonded)

c High Chemical resistance

d High strength in proportion to weight

e Good electrical resistance

f Dimensionally stable

g Low moisture absorption

h Low starting and running friction—particularly when lubricated by water

...and the answer is

FEROBESTOS

TECHNICAL PLASTICS

the non-metallic, laminated asbestos plastics that meet the needs of modern industry.

FERODO LIMITED CHAPEL-EN-LE-FRITH · *A Member of the Turner & Newall Organisation*

METALLURGICAL ENGINEERING

Impact Transition Temperatures and Ageing Properties of Titanium-Stabilised Mild Steels.

By A. JOSEFSSON and B. NELSON. (From *Jernkontorets Annaler, Sweden*, Vol. 137, No. 10, 1953, pp. 725-743, 17 illustrations.)

SOME unalloyed low carbon steels to which titanium has been added—mostly in sufficient quantities for fixing carbon and nitrogen as insoluble titanium carbides and nitrides—have been studied with regard to the transition temperature in Charpy test after straining and ageing, and in some cases also in the non-strained condition. The influence of several different heat-treatments, aiming on the one hand at different grain size in the alpha structure and, on the other, at different cooling rates in the range below 700° C, has also been investigated.

The transition temperatures have been found to lie between —15 and + 50° C after straining and ageing, and between —20 and + 20° C without straining. The lower temperatures are valid for relatively fine structures, and the higher temperatures for coarser structures.

Different rates of cooling in the range below 700° C do not cause any significant difference, such as that obtained in steels with the same base composition, but without titanium.

The absence of quench-ageing and strain-ageing effects has been proved for some of the steels; furthermore, it has been shown by means of internal friction measurements that the quantities of carbon and nitrogen dissolved in the ferrite after quenching from 700° C and 580° C respectively must be very small, below 0·0005 per cent.

METALS CORROSION

Corrosion Aspects of the Vanadium Problem in Gas Turbines.

By S. H. FREDERICK and T. F. EDEN. (From an advance copy of a paper submitted to the *Institution of Mechanical Engineers, London*, November, 1953, 8 pages, 4 illustrations.)

IN this paper, the effects of V_2O_5 and mixtures of V_2O_5 and Na_2SO_4 on turbine fouling and corrosion are discussed. Laboratory tests have shown that none of the commercially available alloys is immune from attack when these mixtures are molten, i.e., at temperatures above 650° C. Nickel base heat-resisting alloys of the Nimonic type offer higher resistance to attack than the austenitic steels, while some degree of protection is afforded by electro-deposited coatings of chromium.

Steels and heat-resisting alloys are not attacked to any significant extent at temperatures below the melting point of the ash, but copper base alloys suffer considerable corrosion at temperatures as low as 500° C.

A detailed investigation of the effect of additives on the corrosion rate of V_2O_5—Na_2SO_4 ashes indicates that corrosion can be considerably reduced, and that such a method of approach to the problem is promising. Suitable additions may be made by a mixture of oil- or water-soluble materials with the fuel, by suspension in the fuel, or by separate injection into the combustion chamber, with the object of reducing corrosion and deposition.

Laboratory corrosion tests, using ash additives, such as Al_2O_3, ZnO, and kieselguhr, have shown that the rate of attack can be greatly accelerated if the additive is present in certain critical proportions, but that, when these are exceeded, corrosion is considerably reduced. With MgO, however, no such increase in attack was noted, but the presence of SO_3 in the combustion gases will reduce the effectiveness of MgO as a corrosion inhibitor. This, however, is unlikely to become significant at temperatures above 700° C, but will grow progressively more serious at lower temperatures.

Rig tests have confirmed some of the beneficial effects of additives.

RHEOLOGY

Geometrical Discussion of the Slip Line Field in Plane Plastic Flow.

By W. PRAGER. (From *Acta Polytechnica, Sweden*, Physics and Applied Mathematics Series, Vol. 2, No. 6, 1953, 27 pp., 13 illustrations.)

MOST of the early work on plane plastic flow is concerned with the stress field only, the boundary conditions being assumed to render the problem statically determinate. Actually, there are only very few practically important problems in which this assumption is justified; as a rule, the boundary conditions involve velocities as well as stresses. While several mixed boundary value problems of this type have been solved in recent years, general methods for treating such problems have not yet been developed, and most solutions so far obtained involve particularly simple slip line fields with at least one family of straight slip lines.

The stress and velocity fields associated with these special slip line fields have rather simple analytical representations and consequently lend themselves well to the treatment of boundary value problems. Unfortunately, straight slip lines nearly always imply rectilinear boundaries, so that these simple stress and velocity fields will not be useful in the case of curved boundaries. Moreover, even in the case of rectilinear boundaries, the given surface tractions or surface velocities may rule out straight slip lines. In all these cases, where the slip lines of both families are curves, analytical or even numerical exploration of the stress and velocity fields is a cumbersome procedure.

The graphical procedure presented in this article seems preferable as a method of treating problems of plane flow of a perfectly plastic incompressible material. The method uses the geometrical relations between the net of characteristics in the physical plane and its images in the stress and hodograph planes. Two examples are discussed, illustrating the method. The first example is a problem of steady flow, while the second deals with the non-steady flow occurring in a notched tension specimen, tested under conditions of plane strain.

STRENGTH OF MATERIALS

Biaxial Fatigue Properties of Pressure Vessel Steels.

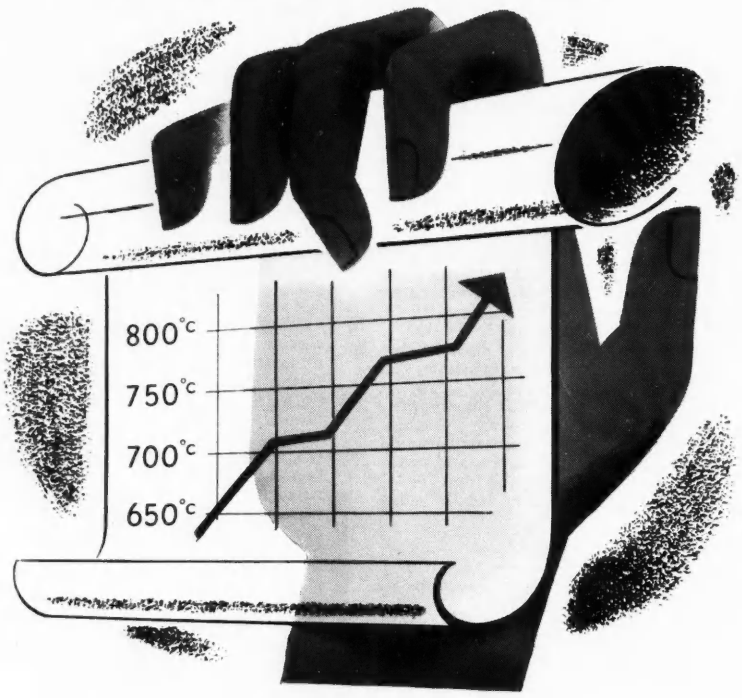
By C. E. BOWMAN and T. J. DOLAN. (From *The Welding Journal, U.S.A.*, Vol. 32, No. 11, November, 1953, pp. 529s-537s, 18 illustrations.)

SOME pressure vessel designers believe that vessels designed, constructed, and operated under the most favourable conditions can safely be fabricated from available high-tensile alloy steel, with design stresses of $\frac{5}{8}$ to $\frac{2}{3}$ yield strength, instead of $\frac{1}{4}$ minimum specified tensile strength, as now permitted by A.S.M.E. codes.

As one phase of a research programme to accumulate experimental evidence on which to appraise the adequacy of design methods, studies were made to determine the resistance of a carbon steel and of a low-alloy steel plate to fracture under repeated loading, and to evaluate the relative strength reduction resulting from stress values imposed by design, fabrication, or handling. Rectangular specimens of $\frac{3}{4}$-in. plate were uniformly loaded as simply supported flat slabs, to develop a state of biaxial tension in the top surface of the central zone of the plate, the principal stresses having a ratio of about 2 to 1. Special loading fixtures and pumping equipment were constructed for the repeated application of a hydraulic load to the specimen.

The steels used in the tests were A201, Grade A, and A302, Grade B, of the following composition :—

HIGH TEMPERATURES?



you need the WIGGIN touch

The selection of the best materials for use at high temperatures is a problem for the expert. That is where we can help. We have research data and service results covering the use of a wide range of materials in various operating conditions.

Amongst this wealth of technical information we may already have the solution to your own high-temperature problem. The chances are that one of our high-nickel alloys will best meet your requirements — *but ask us before you go ahead.*

Useful technical data on our high-temperature materials is contained in our publications. May we send you copies?

WIGGIN HIGH-TEMPERATURE MATERIALS

INCONEL*	NIMONIC 80A
NIMONIC* 75	NIMONIC 90
NIMONIC F	NIMONIC 95
NIMONIC 80	NIMONIC DS

*Registered trade mark

WIGGIN

FOR COLD FACTS ON HOT METALS

HENRY WIGGIN & COMPANY LIMITED, WIGGIN STREET, BIRMINGHAM, 16

	A201, Grade A	A302, Grade B
Carbon, %	0·14	0·16
Manganese, %	0·38	1·44
Phosphorus, %	0·017	0·026
Sulphur, %	0·034	0·032
Silicon, %	0·20	0·27
Molybdenum, %	—	0·43

In general, it was found that the fatigue life of the A302 steel was appreciably greater than that of the A201 steel, when subjected to cyclic strains up to those which exceeded the yield point strain of the A201 steel by as much as 75 per cent. At higher strains, however, this trend was reversed. It was also found that a submerged-arc weld, ground flush with the parent metal, did not reduce the fatigue resistance of either type of steel; furthermore, a notch, having a theoretical stress concentration of 2·8, reduced the number of cycles of repeated load necessary to cause failure of both steels by factors of from 4 to 16 times, depending on the particular stress level and material involved.

WELDING

Cold Welding of Aluminium.

By I. V. BARANOV. (From *Vestnik Mashinostroyenya, Russia*, No. 9, 1953, pp. 86-89, 9 illustrations.)

TESTS carried out in a Russian plant provide interesting information on the cold welding of aluminium alloys. In the simplest process the components are not previously clamped, but the welding punch has a protruding centre which penetrates into the material, causing its plastic deformation. The surrounding surface of the punch then comes into contact with the material. Tests have shown that cold welding takes place in the surrounding zone as well as under the centre of the punch.

The quality of cold-welded spots is judged by their strength or failing load. The height by which the centre punch protrudes has a decisive effect on the failing load. There is no weld below 0·9 mm and the failing load increases progressively up to about 2 mm in the welding of a lap joint between sheets of 2 mm thickness. A strength per spot of 154 lb in sheer and 330 lb in tension can be reached.

The centre punch has a section area of about 15 per cent of the whole. The degree of pressure is therefore characterised by the pressure reached under the surrounding surface. The strength of the weld rises from 200 to 330 lb when the punch pressure increases from 1·9 to 12·7 tsi.

Aluminium sheet and strip up to 2 mm thickness can be successfully cold welded with a solid punch, but the quality deteriorates above this thickness because of the deformation of the surrounding material. Beyond 4 mm thickness, cold welding can be accomplished only by precompression under a hollow punch, followed by the penetration of an inner punch which forms a plunger in the hollow outer punch. This method eliminates the permanent deformation of the components and increases the strength of the weld. This increase can reach 50 per cent.

Weld strength depends on the depth of penetration and is at its maximum when the metal in the centre is completely squeezed out. Clearly, the strength of the weld then depends entirely on that of the peripheral zone. It can be shown that for best results the precompression pressure must be slightly in excess of the yield stress of the alloy. The resistance to penetration first rises steeply, then slowly when the yield pressure has been reached, but finally rises very steeply again after reaching about 70 per cent of the total thickness.

The speed of penetration has no influence on the strength of the joint within the whole range between 0·002 mm/sec and impact speed.

A series of thorough tests has led to the conclusion that, whilst the removal of dirt and grease is indispensable, the removal of the oxide layer is unimportant for a successful cold weld. It appears that the oxide layer is broken in the welding process. In some cases it is therefore possible to use heating in an oven as a method of preparation.

The strength of a multi-spot joint is somewhat reduced by a maldistribution of stress. In a typical case of welding aluminium bars, of 5 × 50 mm cross section, one spot gives a shear strength of about 2100 lb, while two and three spots yield at about 3570 and 5500 lb respectively. At 4 spots the failure is transferred to the bar itself.

It is pointed out that sound electrical connections can be produced by cold welding and that dissimilar metals, such as copper and aluminium alloys, can be welded together.

Current-Slope Control for Resistance Welders.

By R. O. JOHNSEN. (From *Electronics, U.S.A.*, Vol. 26, No. 11, November, 1953, pp. 158-159, 4 illustrations.)

CONTROL of rise and fall of the current envelope in resistance welding is of assistance in increasing weld quality and uniformity.

A gradual rate of increase is helpful in reducing sticking in the spot welding of aluminium materials, magnesium, and their alloys. Tests showed that the number of welds made before sticking occurred could be increased from 20 to 25 times by controlling the up-slope of the welding current envelope. On the other hand, control of the down-slope, or rate of decay of welding current, has an annealing effect, which helps to relieve stresses, and to reduce the possibility of shrinking, cracks, and porosity of temper types of aluminium. In addition, the application of forging pressures is less critical with control of down-slope.

To assist in obtaining and maintaining high-quality welds, a combination up-down slope control has been developed. The control unit embodies a relatively simple electronic circuit, with a short reset time, capable of resetting in one cycle, when interconnected to a seam-welding control. The unit is completely electronic in operation, and has no relays or moving parts.

Up and down slope adjustments control the rate of current increase and decrease. Control of initial and maximum current is provided, to establish the current range through which the slope will operate. A down-slope delay determines the point where the down-slope will start. This delay requires a precision timing circuit, as it determines effectively the end of actual weld time. If this timing is not accurate, the amount of heat energy supplied to the weld will vary, causing inconsistent results. Basically, the control may be considered as a variable resistance inserted in the phase-shift circuit of the main welding control. The phase of the voltage developed across the output transformer is used to control the point on the supply-voltage wave at which the welding ignitron tubes fire. In this phase-shift circuit, an increase in the resistance will cause a decrease in welding current, retarding the firing point of the welding ignitron tubes.

Multi-Electrode Automatic Welding and Surfacing under Flux.

By N. P. EMELYANOV, A. B. OBUKHOV, and D. A. DULCHEVSKY. (From *Vestnik Maschinostroyenya, Russia*, Vol. 9, 1953, pp. 73-78, 12 illustrations.)

THE characteristics of automatic welding under flux do not lend themselves easily to the production of shallow seams or to surfacing. An increase in welding current is accompanied by an increase in penetration and in the percentage of parent metal in the weld.

Multi-electrode welding overcomes these difficulties, as well as the welding of seams of great depth in a single traverse and the welding of ordinary seams at high speed. The several electrodes are fed in parallel and

GOODYEAR BELT GIVES TROUBLE-FREE SERVICE ON INTRICATE DRIVE

Extreme flexibility proved in woodwork factory

FOUNDED as a cooperage in 1878, the firm of Craigs Ltd., Widnes, has steadily expanded ever since. Today it combines a flourishing timber merchanting business with large scale woodwork manufacture for the building, chemical, engineering and textile industries.

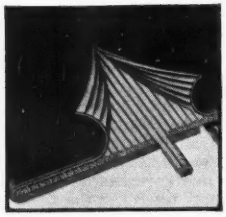
On the manufacturing side, Goodyear transmission belts are giving highly satisfactory performance under the toughest working conditions.

On this sanding machine, for example, a Goodyear Endless Cord Belt is giving outstanding service. Here, the 35 h.p. drive entails six changes of direction, combined with a regular lateral movement of the roller pulleys. Belt speed is over 2,000 feet per minute. Goodyear Endless Cord Belts were adopted after other types of belt had been proved unsuitable for the drive.

WHY GOODYEAR?

Why are Goodyear Industrial Rubber Products so completely reliable? Because they are the result of over 50 years' experience in rubber engineering. Because skilled Goodyear technicians supervise their manufacture at every stage. That is why Goodyear products are giving years of trouble-free service, the world over.

GOODYEAR ENDLESS CORD BELT



A belt with exceptional flexibility that permits greater speed over small pulleys. The load is carried by a central layer of robust, low stretch cords, continuously wound so that joints are eliminated. Balanced construction of the cords and of the tough fabric envelope ensure true running. The Goodyear Endless Cord Belt carries 33⅓ per cent. more load than any other belt of equal thickness.

★ **Goodyear Endless Cord Belts successfully tackle a complicated drive with six changes of direction. This is a sanding machine in the woodwork factory of Craigs Ltd., timber merchants at Widnes. Tough, dependable Goodyear belts are used exclusively throughout the plant.**
(NOTE. The guards have been temporarily removed from this drive to facilitate photography.) ★

Illustrated and informative catalogues are available for all Goodyear Industrial Rubber Products. Please write to Dept. Y, Goodyear Tyre & Rubber Co. (G.B.) Ltd., Wolverhampton, stating the products in which you are interested.

GOODYEAR

INDUSTRIAL RUBBER PRODUCTS

TRANSMISSION BELTING · V-BELTS · CONVEYOR BELTING · INDUSTRIAL HOSE

supplied from a single phase into the zone of the welding arc. The welding process is based on the phenomenon of the automatic arc transfer between the parent metal and the electrodes. A process of arc wandering takes place, wherein the arc always concentrates on the shortest gap under the longest electrode, and thus ensures uniform melting of all. Arrangements in multiples of three, consisting of as many as nine or twelve electrodes, can be used.

The advantage of the multi-electrode method is the fact that, in addition to the welding factors available for selection with a single electrode, the disposition and spacing of the electrodes are added. Thus, in the welding-on of bands it is not possible to reduce the percentage of the parent metal below about 60 per cent, except by the use of several electrodes. Beyond about 35 per cent of parent metal, such welds cannot be preserved from cracking.

It has been proved in tests that welding heads with uniform rate of feed and those with automatically controlled feeds are equally satisfactory. This multi-electrode automatic welding process under flux also shows great promise in the welding of alloy steels and in facing with an alloy layer.

The Welding of Ductile Iron.

By T. E. KIHLGREN and H. C. WAUGH. (From *The Welding Journal, U.S.A.*, Vol. 32, No. 10, October, 1953, pp. 947-956, 15 illustrations.)

IN many applications of ductile iron, or spheroidal-graphite cast iron, weldability is an important consideration, and with the increasingly wide acceptance of this material, the need for more information on its response to welding as a means of repair, fabrication, and salvage has become progressively greater.

This paper deals with the metal arc welding and, to a lesser degree, with the inert arc welding of ductile iron, using nickel-iron electrodes and filler wire. Brief data are also presented on the metal arc welding of this material with steel electrodes.

On the basis of the present investigation, the following broad generalisations, among others, seem justified :—

(1) Ductile iron can be welded by most of the commonly employed fusion welding processes. For maximum welding response, it should be welded in the fully annealed condition, though it can be welded successfully in the as-cast condition, with suitable selection of casting composition and joining process and procedure.

(2) The lower the levels of those alloying elements in the casting composition causing increased weld hardenability, the better is the welding response and the less important is the need for preheating. Phosphorus has an adverse effect on weldability. A maximum of 0·10 per cent is permissible when welding with nickel-iron electrodes or filler wire, and 0·05 per cent if steel electrodes are employed.

(3) Metal arc welding with austenitic nickel-iron electrodes has been applied successfully to a fairly wide range of casting compositions in both the as-cast and annealed conditions, with and without preheating. Inert arc welding with austenitic nickel-iron filler wire seems promising, joints in ductile iron cast plate of preferred composition, welded in both the as-cast and annealed conditions, being readily effected in plate thicknesses up to 1 in.

(4) Ductile iron can be joined to such dissimilar metals as mild steel, stainless steel, nickel, Monel, and Inconel, with austenitic nickel-iron electrodes.

(5) Where machinability is a prime requisite, arc-welded joints should be fully annealed after welding (1650 + 1275° F treatment). A 1275° F post-weld treatment (without the 1650° F prior treatment) may provide an adequate improvement in machining response for some purposes.

(6) Low hydrogen-type mild steel electrodes hold some promise for joining ductile iron, provided that a low-alloy, low-phosphorus casting composition is used, and the castings are welded in the fully annealed condition.

NEW MATERIALS, PROCESSES AND EQUIPMENT.

(*Concluded from page* 480)

working space, thus ensuring precise control of atmospheric conditions, whilst positive circulation of the steam within the retort by means of a centrifugal fan in the base is considered imperative. Furthermore, the retort is the minimum size consistent with the work basket dimensions, enabling a corresponding reduction in operating costs to be effected.

A section through the furnace is shown in the accompanying schematic diagram, where it will be seen that the steam is supplied to the gland box below the chamber, travels up the space around the fan shaft and enters the chamber where it flows over and around the work in the charge basket. The door, of the lift and swing-aside type, is sealed and provided with four clamps. A steam exit is let into the top of the door. Heating is by means of nickel-chromium coil-type elements, mounted in the annular space between the wall and the retort.

A throat in the base of the chamber helps to direct the flow of steam and protects the fan from any work which may be dropped into the retort ; it also forms a platform on which the work basket can rest. The fan shaft assembly is fully protected against the effects of heat and steam, and the shaft is driven by a standard motor through a belt and pulley. The whole of the fan assembly can be attended to without disturbing the elements or retort.

Four standard sizes of furnace are available, having work baskets ranging from 13 in. diameter × 19 in. depth to 28 in. diameter × 38 in. depth.

MACHINE TOOL TRENDS IN THE U.S.A.

(*Concluded from page* 453)

stress the need for either hardened and ground, or hardened-insert type, machine ways. Most users apparently prefer electric control circuits to electronic. The future use of electronic control circuits will grow, but the rate of growth will depend to some extent on the availability in the users' plants of maintenance men who can service them. Machine-drive systems will naturally vary according to the machine and its operation, but the general opinion shows wide acceptance of the V-belt, which is also the most commonly used. There is a constant demand for increased feed rates and most metalworking executives specify higher speed ranges on their machine tools. There is a slight preference for hydraulic feeds as against mechanical feeds. Automatic lubrication systems are specified by the vast majority.

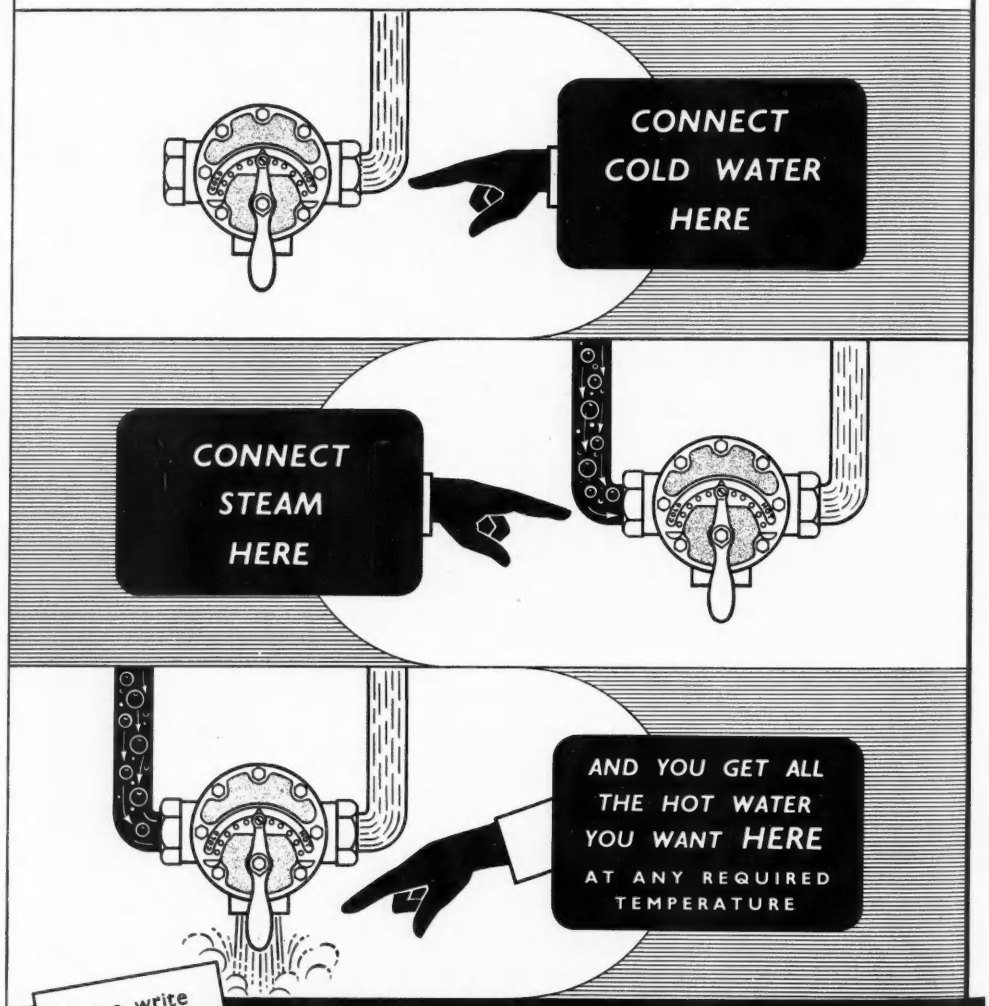
It is interesting to note that, as a result of the recent emphasis placed on the location of hand levers, push-buttons, etc. by machine tool builders, more than 80 per cent of users of present machines consider that controls and levers are already located conveniently.

Not the least interesting thing about this survey is the colossal amount of work involved in securing and collating the information necessary for its compilation, and the interest and co-operation of American manufacturers and machine-tool operators in providing detailed information. The survey itself is instructive, representing as it does a reasonable cross-section of machine-tool trends in the U.S.A. Perhaps, a similar survey in Great Britain would also be fruitful, not only as a means of assessing British trends, but also as a comparison between requirements in America and Great Britain.

Leonard THERMOSTATIC

steam-water HEATER

- Easy to install
- Low Initial cost
- No heat storage losses



Please write for Pamphlet No. 24/S

WALKER CROSWELLER & CO., LTD.
Whaddon Works, Cheltenham Glos.

NEWS OF THE MONTH

PERSONAL

Mr. W. L. Beeby, O.B.E., M.I.Mech.E., M.I.P.E., Ass.I.E.E., has been appointed director, and will be in charge of manufacture, of The Edison Swan Electric Co. Ltd., 155 Charing Cross Road, London, W.C.2.

Mr. B. J. Bradford has been appointed publicity manager of The Rheostatic Company Ltd., Slough, Buckinghamshire.

Mr. F. H. Brooks has been appointed technical director of The Wellman Smith Owen Engineering Corporation Ltd., Parnell House, Wilton Road, London, S.W.1. **Mr. Cyril Brooks** has been appointed general works manager.

Mr. H. B. Cundall has been appointed development engineer of Hunting Air Transport Ltd., Bovingdon, Herts.

Mr. A. W. Daniels, M.I.Mech.E., has been appointed managing director of Holdan Engineers (London) Ltd., 49 St. James's Street, London, S.W.1.

Mr. L. W. Dennis has taken up his appointment as managing director of Cape Asbestos (Canada) Ltd., Manufacturers' Life Insurance Society Building, 200 Bloor Street East, Toronto, Ontario, Canada. **Mr. Dennis** is also chairman of the North American Asbestos Corporation, 141 West Jackson Boulevard, Chicago 4, U.S.A., of which company **Mr. Robert E. Cryor,** formerly with the Union Asbestos & Rubber Company, has been elected President.

Mr. J. T. Fleming, works general manager of the North British Locomotive Co. Ltd., has been elected to the Board of the Company.

Mr. George T. Gedge, works manager of Short Brothers and Harland Ltd., Belfast, has been appointed assistant general manager, **Mr. B. Penney** has been appointed works manager.

Mr. R. Gore, A.M.I.Mech.E., A.M.I.P.E., has been appointed methods engineer of Sheepbridge Engineering Ltd., Chesterfield, in charge of production control, material handling, factory layout and general process planning.

Mr. F. W. Halliwell, M.I.Mech.E., M.I.Prod.E., has been re-elected President, **Mr. A. L. Dennison, M.I.Prod.E.,** chairman, **Mr. S. J. Harley, B.Sc., M.I.Mech.E., M.I.Prod.E.,** and **Mr. L. E. Van Moppes,** vice-chairmen, and **Mr. R. Kirchner, M.I.Mech.E., M.I.Prod.E.,** honorary treasurer, of The Gauge and Tool Makers' Association, Standbrook House, 2/5 Old Bond Street, London, W.1.

Mr. E. V. M. Hughes has been appointed managing director of the London Electric Firm Ltd., South Croydon. **Mr. H. E. Reigate,** secretary, has been appointed a director of the Company.

Dr. J. E. Hurst has been elected a director of the Staveley Coal and Iron Co. Ltd.

Mr. T. W. N. Jameson, Mr. D. R. Watts and **Mr. R. B. Smith** have been appointed to the Board of George Wimpey & Co. Ltd.

Mr. J. R. Kelly has joined the Board of Vickers-Armstrongs Ltd. and has assumed the position of general manager of the Crayford and Dartford Works and the Whitehead Torpedo Works of the Company.

Mr. W. Lyons, chairman and managing director of Jaguar Cars Ltd., Coventry, has been elected President of the Motor Industry Research Association, in succession to Sir Reginald Rootes.

Mr. H. McNeil, director and general manager, has been appointed deputy managing director of Babcock and Wilcox Ltd., Babcock House, Farringdon Street, London, E.C.4. **Mr. J. Stewart Robertson,** assistant general manager, has been appointed general manager.

Mr. A. H. Madden has been appointed divisional motive power superintendent of the London Midland Region of British Railways, Derby.

Mr. C. F. Merriam, chairman of British Xylonite Co. Ltd., has been elected President of the British Plastics Federation.

Mr. S. R. Miller has been elected chairman of Fletcher Miller Ltd., Hyde, Cheshire. **Mr. R. T. Miller, Mrs. M. Agate,** and **Mr. A. George** have been elected to the Board.

Mr. H. G. Nelson, M.A.(Cantab.), M.I.C.E., M.I.Mech.E., M.I.E.E., deputy managing director of the English Electric Co. Ltd., Marconi House, Strand, London, W.C.2, has joined the Board of the Canadian Marconi Company, the controlling interest of which has recently been acquired by the English Electric Co. Ltd.

Mr. F. H. Pollicutt, F.R.Ae.S., has been appointed chief designer of Percival Aircraft Ltd., Luton, Bedfordshire.

Mr. Mark R. Reeve has been appointed a director of Steeners of Tiverton Ltd., Lowman Works, Tiverton.

Rear Admiral G. C. Ross, C.B., until recently director of maintenance and repair, Admiralty, has joined Armstrong Siddeley Motors Ltd., Coventry.

Mr. J. Arnold Rowland, assistant production manager of William Jessop and Sons Ltd., Sheffield, has been appointed planning, production, control and progress manager of the Low Moor Alloy Steel Works Ltd., Bradford.

Mr. S. G. M. Shallard, M.B.E., A.M.I.Mech.E., has been appointed London manager of the Hoffmann Manufacturing Co. Ltd., in succession to **Mr. P. Rhodes,** who is retiring after 32 years of service with the Company.

Mr. W. A. Shaw, A.I.E.E., has been appointed sales director and elected as a member of the Board of Evershed and Vignoles Ltd., Acton Lane Works, London, W.4. **Mr. H. W. Griffiths, A.M.I.E.E., M.S.M.A., M.I.Ex.,** has been appointed general sales manager.

Dr. J. Smillie has been appointed production director of the West Midland Division, and **Mr. J. M. Pumphrey,** production director of the Northern Division of the National Coal Board.

Mr. E. L. Tuff, M.I.Prod.E., works manager of The Projectile & Engineering Co. Ltd., Acre Street, London, S.W.8, has been appointed a director of the Company.

Mr. F. Wale has been appointed managing director of E. G. Brown & Co. Ltd., West Road, Tottenham, London, N.17, in succession to the late **Mr. E. G. Brown.**

Mr. R. H. Weir will officiate as principal director of Engine Research and Development in the Ministry of Supply as from January 1st, 1954. He will succeed **Air Commodore F. R. Banks, C.B., O.B.E.,** who will be released from charge of aero-engine development and return to his firm, the Associated Ethyl Co. Ltd. **Air Commodore Banks** will remain, however, a consultant to the Ministry on aero-engines.

Mr. G. R. Whitehead, manager of the Spotborough Foundry, Doncaster, of John Fowler & Co. (Leeds) Ltd., has been elected a director of the Company.

Mr. H. Williams, M.B.E., T.D., A.M.I.E.E., has been appointed manager of the Worcester Branch of British Insulated Callender's Cables Ltd., in succession to the late **Mr. C. H. Panting.**

(*Continued on page* 490)

CHAPMAN & HALL

Just Published

STATISTICAL METHODS IN ELECTRICAL ENGINEERING

by

D. A. Bell,

B.Sc., PH.D., M.I.E.E.

8¾″ × 5½″ 176 *pages* 28 *figures* 25*s. net*

RELAYS FOR ELECTRONIC AND INDUSTRIAL CONTROL

by

R. C. Walker,

B.Sc. A.M.I.MECH.E., A.M.I.E.E.

8¾″ × 5½″ 320 *pages* 187 *figures* 42*s. net*

WORKSHOP COSTS & COSTING

by

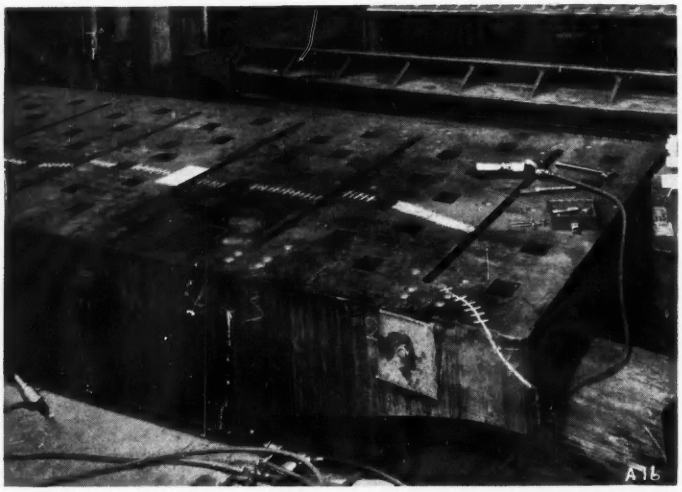
P. S. Houghton,

A.M.I.MECH.E.

8¾″ × 5½″ 308 *pages* 51 *figures* 35*s. net*

37 ESSEX STREET, LONDON, W.C.2

CASTING REPAIRS



This illustration shows the table of a heavy veneer slicing machine which has sustained 16ft. of fracture and was repaired by us at our client's works within four days of notification and is still giving complete satisfaction in all respects.

THE CASTREP METAL STITCHING PROCESS is a cold method for the repair of machinery castings in Bronze, Iron and Steel. As no heat is applied castings are left true and unwarped, no remachining being necessary. Our Engineers carry out repairs on your premises often without dismantling. Should you sustain Machinery breakages the few minutes spent in contacting us may ultimately save you thousands of man hours.

***IT IS A FACT:* OUR PRICES WITHSTAND ALL COMPETITION**

ALL REPAIRS GUARANTEED.

24 HOUR DAY 7 DAY WEEK.

SEND FOR ILLUSTRATED BROCHURE.

Service in: FRANCE, AFRICA, ITALY & GERMANY

BIRMINGHAM:
Phone: Erdington 5011

PORTSMOUTH:
Phone: Portsmouth 6020

BRISTOL:
Phone: Bristol 34976

CASTREP CO.

Metal Stitching Process

Phone: EALING 7923
Grams: CASTREP, Ealux, London
Cables: CASTREP, London
Emergency No: SOUthall 3544

HELENA CHAMBERS · 42 THE BROADWAY · EALING LONDON, W.5

ASPECTS OF PRODUCTIVITY POLICY

Mr. B. H. Dyson, general works manager of Hoover Limited, has recently given a number of addresses on aspects of productivity policy.

He said that without effective sales, there could be no future for production. The constant objective of production policy must be, therefore, to enhance sales. In the immediate post war years, the problem was " How much production ? " Today it is " Production at how much ? " There was a big difference between increased production and increased productivity. Present high costs of production were detrimental to the living standards of the nation. Progressive policy for production necessitated not only the exploitation of mechanical resources but the stimulation of maximum human impetus. Possibly the most dangerous factor in Britain today is our acceptance of the lowering of our standard of expectancy. The high productivity of the most successful British firms resulted from the high standard of expectancy of the managements.

The linking of claims for salary and wage increases to price level changes, without consideration of the volume of production, could mean an attempt to share what, in fact, had not been produced. On the other hand, at a time of rising productivity at constant costs, application of the cost of living principle could deprive salary and wage earners of the benefits of the increase in productivity.

The percentage of direct producing personnel in large organisations in many cases was only 50 and 60 of the total employed, and it might be a better proposition to study the efficiency of the pre-production departments.

Administrative departments untuned or out of step with production requirements could seriously affect productivity. There should be a clear definition of function and responsibility so that each man knows the part he has to play. All people prefer and respect a good leader, and if the official leader fails, the unofficial leader whether he be the personnel manager, the shop steward or the noisy agitator, will soon influence the group.

How many managers made a daily tour of their offices and factory and showed their personal interest ? With no goal post, there could be no goals, with no winning post and time recording device, there could be no measurement of achievement. Similarly, with no targets and measurment of achievement in an industrial organisation, there could be no increase in productivity.

Office work was equally as important a production cost as machine shop operations, and in offices there were unlimited opportunities to increase both individual office worker output and machine utilisation.

As a result of a recent investigation in a certain company, 9 per cent of its printed forms were deleted, 12 per cent were modified. The modification included re-designing the forms to conform with the spacing and line-up with the typewriters in current use. The total saving was calculated at £4,500 per year.

Research into design for production is the first stage towards productivity. Research under this heading includes reduction of the number of component parts, the standardisation of detail and the reduction of production operation processes.

As an example Mr. Dyson mentioned his own organisation where the total number of components on one particular product had been reduced from 764 to 508 and the number of sub-assemblies from 59 to 45.

Research into material utilisation, resulted at Hoovers in considerable reduction in the amount and weight of material required, particularly by the purchase of raw material in economical condition or length.

By redesigning a particular product using modern manufacturing techniques, they had been able to reduce the weight of material required per 100 assemblies from 64 lbs to 30 lbs.

In countries where production was higher than in Great Britain, people did not work harder but more continuously and effectively. Particularly they have more horse-power to their elbow. In Britain, even in otherwise well-equipped factories, office workers are often without simple adding or calculating machines ; even worse, electricians and carpenters still use simple hand tools, yet portable power tools had been available for years.

Very few tool designers, draughtsmen or tool makers knew the comparative times of locating a component, and the loading, locating and cleaning time of tools and fixtures is comparatively unknown.

As a result of research into jig and fixture design, with a view to synchronising the use of both hands and blind approach location and operating guards, Hoover Limited had considerably improved quality, safety and productivity. Wherever possible, they have designed twin tools to accommodate two components at one operation. The cost was 55 per cent more than a single tool, but productivity was increased by 73 per cent.

Materials handling operations in the engineering industry greatly outnumber direct manufacturing or process operations and should receive the same detailed consideration at the planning stage, as for instance, machine design and process technology. A feature of the Hoover shops was the closely integrated lay-out, in which work had to travel only minimum distances from operation to operation. Idle time had been eliminated by the grouping of machines to allow one operator to serve several or to carry out subsidiary operations during the automatic cycle of the primary machine in the group.

The benefits to be obtained from work study can be described in relation to pre-production planning, effective operation and managerial control. These aspects were equally pertinent to both direct and indirect activities and to manual, machine or clerical tasks.

A unit of time is a universally accepted standard making possible even international comparisons and for this purpose the basic circumstances of time study must be defined and there must be agreed practices and procedures.

The people responsible for production processes and procedure, must have the all embracing view stretching from material suppliers' door to customers' door. Such studies would result in the obviating of much unnecessary work in the handling of material from suppliers direct to the first production operation.

The qulaity of a product emanates from the skill and accuracy of the person manufacturing the component. Hoover Limited had paid great attention to the design and provision of setting fixtures and high quality checking apparatus for the use of the person actually carrying out the manufacturing operation.

Often factories neglected to define, in the process operation sheet, the inspection operations stating in detail the dimensions and points which needed checking. Viewing and inspection should be carried out in the production flow line and not in some remote department.

The standard of plant utilisation in British industry is very low, often in the region of only 40 per cent. Where capital investment was high, two and three shift working contributed to low cost and higher productivity.

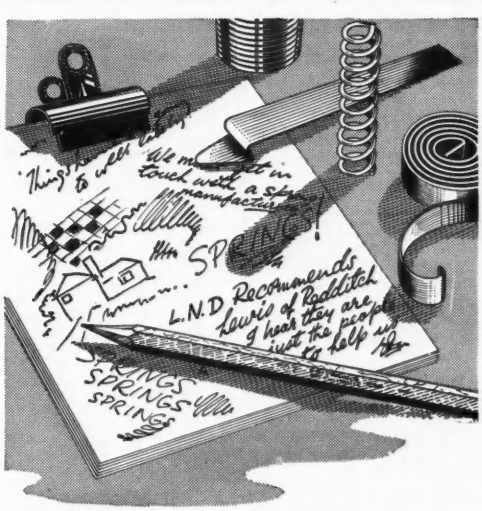
Possibly the only real incentive is that motivated by personal enthusiasm, the " desire " incentive. People desire to be associated with success, to know that they were at and to know what the other fellow was at too. Management should capitalise on these desires.

Mr. Dyson stressed the importance of versatility and also in fostering the team spirit by payment for group output against given targets.

In conclusion Mr. Dyson said that he was convinced that to make an increase in productivity possible there was required a standard of measurement by which targets of expectancy could be set and against which results can be compared. While no one system would do for all industries, if as a result of applying a standard, remedial action was taken, improvement in productivity could be immediate and lasting.

In the Hoover factories it had been possible to show a progressive increase in productivity of 21·7 per cent per annum. The main headings under which this improvement could be allocated were as follows :

Product Design	25%
Utilisation of Material	15%
Capital Investment of Plant	20%
Tooling and Methods	15%
Floor Layout and Material Handling ..	12%
Training of Staff—Aptitude and Effort	13%
	100%



L.N.D. certainly knows what he is talking about. Lewis of Redditch design springs to do just the job you want, and they turn them out from top-quality materials so that they will last as long as your product. It might be worth while to have a word with us, don't you think ?

LEAVE IT TO Lewis OF REDDITCH

THE LEWIS SPRING CO. LTD.,

(Springs, Spring Clips, Presswork, Wire Forms)

Resilient Works, Redditch. Telephone : REDDITCH 720/1/2

London Office : 321 HIGH HOLBORN, W.C.1. Phone: Holborn 7479 & 7470

ROCKHARD
HAMMER FINISH

The new Rockhard 505 two-tone Hammer Finish has been evolved to meet the demand for a material which is foolproof in application — even vertical surfaces can be sprayed without any special care. 505 gives a constant pattern under all conditions.

Outstanding Features of Rockhard 505

One full coat is sufficient

Economical in use

Excellent finish

Easily applied

Reasonable in cost

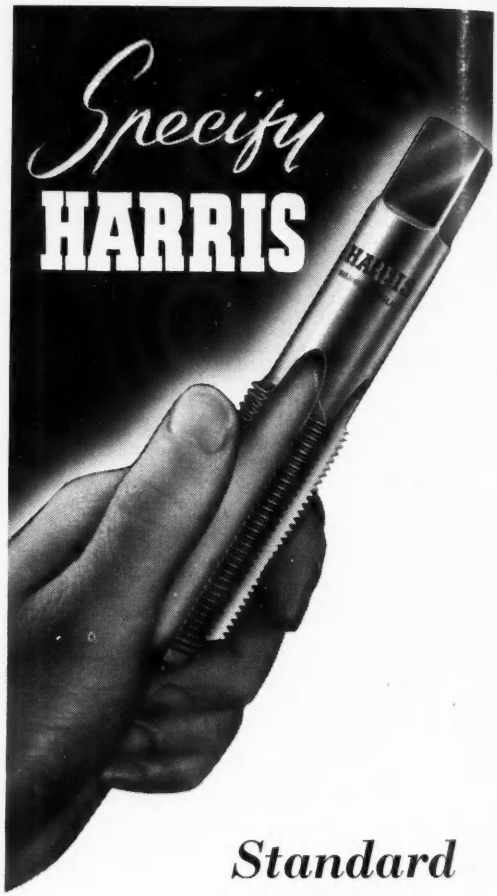
Needs normal spray gun equipment only

Write in now for further information on Rockhard 505 or telephone and ask for a technical representative to visit you.

GITTINGS & HILLS
LIMITED

TOWER VARNISH WORKS, LONG ACRE, BIRMINGHAM, 6.

Telephone: EAST 0297/0298.



Standard

GROUND THREAD TAPS

from stock

Your safe standard tap for all the "fussy" jobs as well as the straightforward ones.

All Harris Taps are precision ground from the solid to give you more accurate threaded holes, faster and at lower cost.

JOHN HARRIS TOOLS LTD

WARWICK, phone: 1041 (4 lines)

The programme of improvement also resulted in post war productivity per square foot of floor space being increased by 45 per cent. Moreover, the combined cost of scrap and re-operation was reduced to 1·5 per cent of the direct factory cost.

This experience suggests that it seems reasonable to suppose that in British Industry as a whole a progressive increase in productivity of 10 per cent per annum is possible. At this rate, productivity in Britain could equal that in America in ten years.

THE METAL THAT TOOK WINGS

When metal took the place of wood and string in the construction of aeroplanes, it was Man's greatest stride forward in his mastery of the air. Today it is worth recalling that this great development was the work of a very small group—one might almost say of one man.

About the year 1908 investigations were being conducted at Woolwich into the feasibility of using aluminium in alloyed form, for the manufacture of cartridge cases. Alloys of many compositions were devised and innumerable trials were made to produce and fabricate strong, light alloys which could be successfully deep drawn.

Some of these alloys contained copper and magnesium, and it was noted that their behaviour was quite unusual, for they became harder and stronger quite spontaneously with the passage of time. While this work was proceeding, the results of Wilm's work in Germany were published, and it became known that light alloys of a strength comparable with mild steel were feasible. One of the young men associated with the work at Woolwich was Horace William Clarke, a young metallurgical engineer, and it is to him more than to any other man that this country owes its pre-eminence in light alloy development. Only those intimately associated with the exacting technique which aluminium alloy production demands can visualise the difficulty of the problems which had to be solved.

Vickers Limited were quick to see the potential value of the new development and Horace Clarke was invited to join them. A small factory was set up in Aston, Birmingham, and with their help, the assistance of a few quite inexperienced labourers and the co-operation of a small local company which had a rolling mill and an extrusion press, he was able to get down to the problem of producing the new material commercially. This was in 1911; and by the early months of 1914, the more immediate problems had been solved, and sheet, strip, tubes and extruded sections were being produced in small quantities. This was the beginning of "Duralumin" in this country and was the root from which all subsequent British developments sprang.

It is to Horace Clarke's credit that his small but enthusiastic team had worked out in Birmingham a new technique in melting and alloying methods; repeated failures to work the intractable castings in this new alloy had been overcome, a delicate and dangerous series of experiments in large scale salt bath heat-treatment had been tackled and brought to a successful conclusion, but there still remained innumerable problems of even greater magnitude before a satisfactory commercial product, free from blemish and of consistent strength, was achieved.

It was at this stage that the wiseacres began to shake their heads. This was an interesting new toy, but enough money had been spent on it. It would be prudent to abandon the project. Fortunately for the country, Horace Clarke had a combination of vision and character which enabled him to see the vast potentialities of the new development, to overcome the scruples of the doubters, and to launch the new metal commercially.

When the war clouds broke in August, 1914, Britain was ready for adventure in a new medium, the air, and "Vickers' Duralumin" was on the market.

By 1915 the small company which had provided the extrusion press for the early experiments was absorbed in the new venture, and the long association of James Booth & Co. Ltd. with "Duralumin" began.

Only a small number of the personnel now engaged in the Aircraft Industry will remember how much was achieved in aluminium alloy technology in the first world war—the Airships, the famous *R* series, were begun, crankcases for the famous "Jupiter" engine were cast and forged, pistons were produced in large quantities, wire, rivets, sheet, strip, section, tube and rod were available in a wide variety of sizes, and the famous Fairey-Reed propeller blades were made in thousands. What these developments meant to the efficiency of the old Royal Flying Corps is now a matter of history, for the new alloy enabled materials to keep step with the ambitious projects of the designers.

In the period between the two wars, development continued, and in 1928 James Booth & Co. Ltd. became an independent concern with Horace Clarke as its managing director. When the second world war broke, history was to be repeated on a larger and grander scale.

The Hurricane and Wellington, the Spitfire and the Lancaster and all the other names that became household words, made new demands for stronger alloys and greater productivity targets. In spite of the difficulties of those days, these demands were met, and this was in no small measure due to the programme of research which the Company had pursued in the years prior to the war.

As early as 1935 Horace Clarke had anticipated the need which would arise for larger forgings in light alloys, and by 1937, with his characteristic foresight, the Company had installed and was operating a 12,000 ton hydraulic forging press.

This was the largest press of its kind in the country—even today none of larger capacity yet exists—and prior to and during the war years, it produced more than 250,000 propeller blade forgings. Its value as a national asset in the defence of the country was incalculable, and faced with the risks of damage from enemy bombing, the Government decided, in the interests of security, that the Company should instal a duplicate press in a different location.

In 1940 the Company was engaged on secret work for the development of alloys and methods of production which were later used in the manufacture of the then unknown jet engines, and was carrying out extensive work on the production of even stronger alloys which, in the later years of the war, were incorporated in the higher speed machines then coming off the production lines.

Since the cessation of hostilities, the story of achievement has gone on. The products of James Booth & Company Limited are still filling demands for the newer military aircraft which have led the world in design and performance, and "Duralumin" has also played a noteworthy part in atomic research.

In the arts of peace, too, the Company's products are to be found in the jet propelled air liners which daily break new records, and in the diverse fields of ship-building, transport, engineering and electronics.

FIRST BRITISH PRESSURE-CHARGED GAS ENGINE

The introduction of the first British Pressure-Charged Gas Engine, capable of developing the same power as most commercial diesel engines in operation to-day, is announced by the National Gas and Oil Engine Co. Ltd., of Ashton-under-Lyne, Lancs. This engine is reputed to be the first pressure-charged gas engine in the world to run on "town" or manufactured gas with a hydrogen content of approximately 50 per cent.

Development commenced on a single cylinder engine of 12 in. bore by 15 in. stroke, running at 428 rpm. Air and gas were provided by Rootes-type blowers and the necessary surge tanks were fitted.

The cylinder head contains an air inlet and an exhaust valve, each in separate cages, the exhaust valve cage being water-cooled. In addition, the head contains the usual compressed air starting valve. Gas is admitted to the cylinder through a conventional poppet valve, which is operated by means of a pushrod from a separate cam on the camshaft. Thus, the gas fuel is prevented from mixing with the air until it is in the combustion chamber. The engine operates on the four-stroke cycle and gas is injected into the cylinder over a pre-determined period of the induction stroke. Full scavenging of the cylinder is obtained as in the conventional exhaust supercharged oil engine working on the Buchi principle, but gas is not permitted to pass through the cylinder during the scavenging period.

In view of the success achieved on the single cylinder engine, it was decided to work on a multi-cylinder engine. There was available in the Works power-house a 6-cylinder National type F4AU oil engine of 11 in. bore by 15 in. stroke, and this was converted by fitting new cylinder heads. Pressure charging is by means of a Brown Boveri exhaust driven supercharger on the Buchi system, with after-cooling of the compressed air. Town gas is available at a pressure of only 5 in. water gauge and this is boosted to 6 psi by a motor-driven Rootes-type blower. An intercooler is fitted on the gas booster outlet in order to study the effect of gas temperature on engine performance.

The high-tension magneto for ignition purposes is driven from the free end of the camshaft, which also drives the air distributor for compressed air starting. A common rocking shaft, coupled to the governor, operates the air and gas throttles. The gas throttles, one to each cylinder, are coupled to the rocking shaft by means of adjustable links, which makes balancing of load between the cylinders an easy matter.

The engine has operated satisfactorily at loads up to 130 psi bmep, with gas consumption at the latter load of 6,800 B.T.U./bhp hour nett. This corresponds to a brake thermal efficiency of 37·4%, which is equivalent to an oil engine consumption of 0·368 lb/bhp hour with fuel oil of nett calorific value of 18,500 B.T.U./lb. The engine develops 600 bhp at 428 rpm on straight gas.

The National Company is fully prepared for the demands to be met by these developments and is producing a comprehensive range of supercharged gas and dual-fuel engines. Of these the F2AUG series have 3, 4, 5, 6, 7, or 8 cylinders, of 12 in. bore by 15 in. stroke, and have a 12 hour bhp rating of 390 to 1040, and a maximum governed speed of 500 rpm, with a maximum mean piston speed of 1250 fpm and a full load bmep of 121 psi. The B2AUG series have 5, 6, 7, or 8 cylinders, of 17 in. bore by 21½ in. stroke, and have a 12 hour bhp rating of 1250 to 2000, and a maximum governed speed of 333 rpm, with a maximum mean piston speed of 1200 fpm and a full load bmep of 121·5 psi.

All engines in these series are vertical, four-stroke, pressure charged. They have compressed-air starting, electric ignition, and a guaranteed full load fuel consumption of 7000 B.T.U./bhp hour.

NEW TECHNIQUE FOR BRAZING STAINLESS STEELS IN A CONTROLLED ATMOSPHERE

It is essential when making brazed joints, that the surfaces to be joined are kept clean so that the brazing metal may wet them freely; the necessary cleanliness may be achieved either by the use of flux or by brazing the component in a controlled atmosphere. Fluxes usually have the disadvantage that they need to be completely removed after brazing to prevent subsequent corrosion. On the other hand, brazing of stainless steel in a controlled atmosphere has not always proved consistently satisfactory. A technique whereby the brazing of stainless steels can be carried out in a standard furnace provided with a controlled atmosphere has now been developed by The General Electric Co. Ltd. The process is suitable for copper-brazing stainless steels and for brazing components using Nicrobraz alloy as the filler metal.

The protective atmospheres most widely used in the process are burnt town gas or burnt ammonia. The brazing of metals which are not easily oxidised, such as steel, may be carried out in these

Smith's technical book service

Books on the latest developments in every aspect of engineering can be obtained from any branch of Smith's. Books not actually in stock can usually be supplied within a day or so. Smith's Postal service can send books to any address at Home or Overseas. Lists of the standard works on any subject quickly supplied on request.

W. H. Smith & Son

FOR TECHNICAL BOOKS

HEAD OFFICE: STRAND HOUSE, LONDON, W.C.2

THE ARIEL
ELECTRIC ERASING MACHINE

An essential for the modern drawing office, enabling modifications to be made without fatigue, in a fraction of the time taken by hand erasure and reducing any ill effects to the drawing surface.

★ Well balanced.

★ Easy to use.

★ Economical and efficient in use.

Supplied complete in box with long flex, spare plug erasers and erasing shield.

Illustrated folder will be forwarded on application.

HALL HARDING LTD.

STOURTON HOUSE • DACRE STREET • LONDON • S.W.1 • PHONE: ABBEY 7141

atmospheres, using filler metals such as copper or copper alloys. However, when components of the stainless steel type are to be treated it is necessary to maintain close control over the quality of the atmosphere within the furnace chamber. Traces of oxygen, water-vapour or carbon dioxide will form an oxide film on the surface of the components which prevents the liquid brazing metal from alloying with the exposed surfaces and a sound joint being made. Similar considerations apply when the brazing alloy itself is readily oxidised, as is the case with certain high temperature brazing alloys such as Nicrobraz. If a very dry hydrogen atmosphere is used and if treatment is carried out in a metal container, the surfaces are kept clean and brazing is satisfactory.

A G.E.C. 60 kW vertical cylindrical furnace with gas tight container has given excellent results when used for the process. It has effective loading dimensions of 17 in. diameter by 4 ft 10 in. deep and can be used for all types of brazing in the temperature range 700°-1180° C. The method of operation is as follows :—

(a) After loading the stainless steel assemblies on the support casting, the pot is sealed and immediately purged with the dry hydrogen protective atmosphere. If it is considered desirable, the pot may first be purged with nitrogen.
(b) The pot is loaded into the furnace and the charge brought to the required temperature in the controlled atmosphere and held at that temperature for between 10 and 30 minutes, depending upon the brazing alloy being used.
(c) The pot is removed from the furnace and cooled under the protective atmosphere.

The holding time at high temperature is short; for most filler metals 10 minutes is sufficient but when Nicrobraz is used a suitable holding time has been found to be 30 minutes.

NEW FORCED AIR CIRCULATION OVEN FOR LABORATORY WORK

A recent addition to the range of low temperature ovens made by The General Electric Co. Ltd. is an easily transportable unit intended for laboratory work. It incorporates all the features required to permit checking and controlling movement of components during tests involving long periods of heat treatment.

The oven has a standard double-case construction with ample heat insulation, and a full length door at the front. Forced air circulation is provided by a centrifugal fan mounted in the roof and driven by an induction motor. Sheathed wire elements are mounted on the side walls behind metal shields which protect the charge from direct radiation and at the same time form part of the air circulation system.

The oven has internal dimensions of 3 cubic feet, and is rated at 9 kW. Its temperature is controlled by an expansion thermostat and the oven is provided with temperature indicator and recording instruments, door switch, and pilot lamps. Maximum operating temperature is 350° C. Through connections are provided at the rear of the oven for external and internal connections to thermocouples for checking charge temperatures.

INDIAN BLASTING EXPLOSIVES PROJECT

As a result of agreements reached between Imperial Chemical Industries Ltd. and the Government of India, a new company is to be established in India to manufacture the country's requirements of commercial blasting high explosives. The Government of India has desired for many years to see India self-sufficient in the manufacture of these essential industrial explosives, the demand for which has greatly increased owing to the development of mining, and to the large public expenditure on water, power, and irrigation works, and on road building.

The company will be known as Indian Explosives Ltd. Initially, Rs. 2 crores (£1½ m.) of capital will be issued, of which 80% will be subscribed by I.C.I. and 20% by the Government of India. The balance of the capital required will be met by loans.

A site has been selected for the factory near the Bihar coalfield, the coal mining industry being the principal consumer of industrial explosives in India. I.C.I., through their Nobel Division, will be responsible for planning the layout of the works and providing designs for the plant and equipment, and will be responsible for its erection and setting to work. I.C.I. will also provide all the technical knowledge required to operate the factory, as well as information on research. They will be drawing on their long experience of blasting explosives, which dates back to 1873, when Alfred Nobel established the first factory in Great Britain for the manufacture of high explosives containing nitroglycerine. I.C.I. will provide initially all management staff required and a number of key workers. The factory will give direct employment to about 400 persons in all. I.C.I. has undertaken to train Indians to take over responsible positions.

By agreement with the new Company, I.C.I. (India), who have been acting as agents in the import of explosives manufactured by I.C.I. in the United Kingdom, will handle the distribution and sales of Indian-manufactured explosives. I.C.I. (India) will operate the extensive series of magazines which they own throughout the country and will continue to give the technical service to which consumers in India have become accustomed. I.C.I. (India) will also act as Secretaries to the new Company; in this capacity they will perform those services which are more easily conducted in Calcutta than at the factory.

Agreements embodying these arrangements have been concluded after discussions in New Delhi between the Ministry of Commerce & Industry of the Government of India and a Mission from I.C.I., including Head Office staff from London and technical staff from the Nobel Division of I.C.I. in Scotland. The Mission was accompanied and assisted by I.C.I. (India) staff. The agreements were signed on behalf of I.C.I. by Mr. R. C. Todhunter, one of the overseas directors on I.C.I.'s Main Board.

The establishment of this new company adds a new manufacturing activity to those which I.C.I. undertakes in India through its Indian subsidiary company the Alkali & Chemical Corporation of India Ltd., which manufactures heavy chemicals and paints and I.C.I. (India) Ltd., which formulates dyestuffs and manufactures plastic film.

BUSINESS NOTES

The British Thomson-Houston Company Ltd. have recently announced a 10-year programme for the expansion of their turbine business, designed to maintain their undisputed reputation in the Industry during the last half century.

The programme consists of two parts involving extensive re-equipment and re-organisation of their Rugby turbine plant and the erection of a new factory in Larne, Northern Ireland. This new factory will concentrate on the manufacture of large turbo-alternators, of 30,000 kW and upwards, and will be built alongside the turbine blading factory already under construction by the Northern Ireland Government.

Manufacture of turbo-alternator sets below 30,000 kW, gas turbines, marine main and auxiliary equipments, compressors, etc., will continue at Rugby but on a greatly increased scale.

This 10-year programme will provide increased employment in the Rugby Works and, in addition, will make a valuable contribution towards the reduction of unemployment in Northern Ireland.

G.W.B. Electric Furnaces Ltd. announce that as from January 1st, 1954, the name of the company will be G.W.B. Furnaces Ltd. The policy and administration of the company and addresses of the company's registered offices, works and branch offices will remain unaltered. The company remains a separate entity, wholly owned by Gibbons Brothers Ltd., of Dudley, and Wild-Barfield Electric Furnaces Ltd., of Watford.

The products of the company include electric resistance, arc and induction furnaces; steam raisers and water boilers heated by oil, gas and electricity, electric control gear and case hardening compounds.

Announcements regarding the new products now in course of development will be made from time to time.

Crompton Parkinson Ltd. announce that their London Plant Branch Office has moved to 1-3 Brixton Road, London, S.W.9. Tel. No. RELiance 7676. **Mr. K. Younger** is manager of the London Plant Branch and **Mr. R. C. Gorringe,** manager of the C.P. London Supplies Branch, situated at the same address.

The Annual Exhibition of the Television Society is to be held at the Electrical Department of King's College, Strand, London, W.C.2, on Thursday, 7th January, 1954, 6.0 p.m.-9.0 p.m., Friday, 8th January, 12.0 noon-9.0 p.m., and Saturday, 9th January, 10.0 a.m.-9 p.m.

Approximately 40 companies are exhibiting a wide range of television equipment for both commercial and industrial application and many new research items will be on show for the first time.

Free admission tickets may be obtained from The Television Society, 164 Shaftesbury Avenue, London, W.C.2.

A "Production for Plenty" Exhibition will be held at Olympia, London, during July, 1954. The Exhibition will be sponsored by the Institution of Production Engineers and will be organised by the Building Trades Exhibition Ltd. The main purpose of the Exhibition and the Conference which is to take place at the Exhibition is to show how improved production methods are reducing the time lag between Research and Production and how Research into greater productivity facilitates the manufacture of more, better and cheaper products.

Further information may be obtained from the Organising Secretary, Mr. S. D. Cooke, Room 11, Avenue Chambers, 4 Vernon Place, London, W.C.1, or from the Secretary, The Institution of Production Engineers, 36 Portman Square, London, W.1.

Maiden & Co. Ltd., manufacturers of screwing machines, Hyde, Cheshire, announce the appointment of Messrs. Reynolds & Wilson, 58 Victoria Street, London, S.W.1, as their representatives for London and the Southern Counties.

International Combustion Ltd. and **Carl Still,** the well-known European designers of coke-oven plant, announce that their extensive technical resources have been combined in a new organisation which has been established under the name International-Carl Still, with offices at 19 Woburn Place, London, W.1. The new organisation will design and construct coke-ovens and by-products plant of the most up-to-date design.

PERSONAL—*continued from page 487.*

Dr. Horace W. Clarke has been elected chairman of James Booth & Co. Ltd., Argyle Street Works, Birmingham 7, in succession to **Sir Bernard D. F. Docker, K.B.E., J.P.,** who continues as a member of the Board.

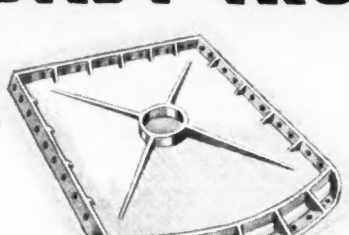
Mr. L. H. Cooper, chairman of The Mond Nickel Co. Ltd., has been elected vice-president of the parent company, The International Nickel Company of Canada Ltd.

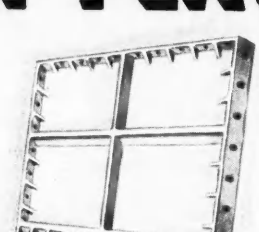
Mr. J. R. Harding, B.Sc.(Eng.), M.I.E.E., has been appointed general manager of Pirelli-General Cable Works Ltd.

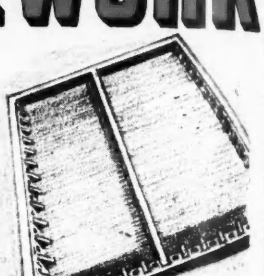
Mr. M. E. O'Keeffe Trowbridge, B.Sc., A.C.G.I., A.M.I.Chem.E., has joined Sharples Centrifuges Ltd., Stroud, Gloucestershire,

Mr. Harold W. Secker, O.B.E., joint managing director of Thos. W. Ward Ltd., Sheffield, director of Parkgate Iron & Steel Co. Ltd. and a number of companies in the Thos. W. Ward Group, has been elected chairman of Thos. W. Ward Ltd., in succession to **Mr. George Wood, C.B.E.,** who retires from the office of chairman as from January 1st, 1954, and has been elected vice-president of the company. **Mr. Arnold Carr** has been appointed assistant managing director, and **Mr. Rawson F. Stagg,** local director, has been appointed a full director.

CAST IRON PLATEWORK







We have recently modernised and extended our heavy mechanised foundry and are able to produce promptly and efficiently all types of cast iron platework suitable for machine moulding in boxes up to 7′ 6″ x 5′ 6″

OUR REPRESENTATIVES WILL BE HAPPY TO CONSULT WITH YOU IN REGARD TO YOUR REQUIREMENTS LARGE OR SMALL

NEWTON CHAMBERS

& CO. LTD. THORNCLIFFE, Nr. SHEFFIELD

BOOKS RECEIVED

The Design of Dams. By A. Bourguin (translated by Frank F. Fergusson, M.I.C.E., F.G.S., M.A.S.C.E.). 357 pp., 263 illustrations. Publishers: Sir Isaac Pitman & Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price: 45/-.

In recent years there has been considerable development in the method of design of dams in connection with hydro-electric power schemes. In this book, the author, who is Professor in the School for Hydraulic Engineers at Grenoble, sets out clearly the theories of the design of gravity dams, arch dams, and counterfort and hollow dams.

Whilst a reasonable knowledge of the strength of materials, statics, and graphic statics has been assumed, Part I of this work has been devoted to establishing formulae and theorems to which references are later made. Part II deals with gravity dams and gives a clear exposition of the well-established method of design. The theory of arch dams is not yet fully established and is still the object of widespread research; the reader will therefore find Part III of particular interest, inasmuch as it deals with the theoretical methods of design available for this type of dam. Part IV is devoted to counterfort and hollow dams.

This book, which is the result of many years of experience, should be of great value to practising engineers and to students.

A Handbook on Die Castings. By F. D. Penny, B.Sc.(Eng.), in collaboration with members of the Advisory Committee (Die Casting), Ministry of Supply. 88 pp., 44 illustrations. Published 1953 by Her Majesty's Stationery Office, London. Price: 6/-.

This book has been prepared at the request of the Advisory Committee (Die Casting), Ministry of Supply, Shell Mex House, London, W.C.2, with the intention of facilitating the work of the Committee by assisting the designer:—

(a) To appreciate fully the advantages and limitations of die-casting processes.
(b) To assess the suitability of a particular component for production as a pressure or gravity die casting.
(c) To make the best choice of materials available.
(d) To design components so as to take full advantage of the potentialities of the process and material chosen.

In addition, the information contained in this volume should be of assistance to those concerned with the inspection and acceptance of die-cast stores.

The Manufacture of Iron and Steel. By D. J. O. Brandt, B.Sc., A.R.S.M., A.I.M. 384 pp., 208 illustrations. Publishers: English Universities Press Ltd., St. Paul's House, Warwick Square, London, E.C.4. Price: 15/-.

This new book on the manufacture of iron and steel has been written with the full co-operation of the British Iron and Steel Federation and the City and Guilds of London Institute, and is mainly intended for operatives in the industry, practical procedures therefore being specially emphasised.

Special features of this book, which forms part of the City and Guilds Series, are the revision chapters incorporated at the end of each section, and the illustrations, which have been carefully chosen as representing the latest developments and techniques.

This authoritative work should be of great value to the operative, the student, and the administrator.

Machine Shop Practice. By W. C. Durney, M.I.Mech.E., A.M.I.Prod.E. Third Edition, 1953. 205 pp., 387 illustrations. Publishers: Sir Isaac Pitman & Sons Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price: 12/6.

This authoritative textbook has been revised and brought up to date with the latest practice, and adequately meets the requirements of students and apprentices taking an Ordinary National Certificate course in production engineering, as well as of those studying for the City and Guilds of London Intermediate Examination in machine shop engineering.

This volume describes the fundamental operations necessary for processing fairly standard light-weight work, variations of which may be found in any engineering machine shop. All operations are listed in practical sequence and are illustrated by accompanying diagrams. In addition, many questions from past examination papers in machine shop engineering are included.

Dubbels Taschenbuch für den Maschinenbau. Edited by Dr.-Ing. F. Sass and Dipl.-Ing. Ch. Bouché. In two volumes, 1631 pp., approx. 3000 illustrations. Publishers: Springer-Verlag, Reichpietschufer 20, Berlin, W.35. Price: DM 37.50.

This famous engineering reference book (in German), which can usually be found in every German design office, has been regarded as a standard work for so many years that this new edition will be welcomed by all who are familiar with previous issues.

The first edition, compiled by H. Dubbel in 1914, met with such outstanding success that, by the time of his death in 1947, no less than nine editions had been published. The current edition is in every way a worthy successor and incorporates the work of several new collaborators. The previous edition has been completely revised and has been brought into line with modern practice; several new chapters have been added, while others have been expanded or entirely rewritten.

In short, to those who require a comprehensive reference book on mechanical and electrical engineering, this work should prove of immense value. Incidentally, previous editions have been translated into Italian, Spanish, and Russian, and there can be no doubt that an English translation would be a welcome addition to the reference library of any designer in this country.

LATEST INDUSTRIAL LITERATURE

1. Integrating Watt-Hour Meter. Full technical data on a new integrating induction watt-hour meter are contained in a 12-page illustrated catalogue. This meter is of the maximum current rating type, is constructed in three sizes (10, 40, and 80 A), and complies with the latest British Standard 37, Parts 1 and 2.

A patented braking system is incorporated, employing four anisotropic magnets, mounted two above and two below the rotor, thus ensuring that the effective braking flux is uniform across the gap, thereby avoiding errors which could otherwise occur.

2. Stirring Gear. A steam-driven stirring gear is described and illustrated in a pamphlet. This gear has been designed to drive steam jacketed mixers, with capacities ranging from about 100 to 500 gal, and its three-cylinder radial engine utilises the steam already raised for heating, thereby doing away with the need for any additional power installation.

The engine, which has a large power reserve, provides variable mixing speeds, ranging from 1 rpm to any desired amount.

3. Clad Steels. A leaflet describes a range of clad steels for chemical equipment. The range comprises stainless clad steel for pressure vessels, storage tanks, etc.; monel clad steel for such items as oil sulphonators and fruit juice tanks; and nickel clad steel for salt dryers, caustic soda equipment, etc.

4. Power Ducting. A leaflet illustrates and describes a power ducting system, which consists essentially of a duct containing the busbars, with a rubbing contact brush-carriage on wheels, running in the duct.

The system can be used for feeding portable electric tools from standard high-fequency, single-phase or three-phase supply up to 440 V, and is especially suitable for mass-production assembly lines and for pattern-making shops, repair shops, etc. It is also suitable for feeding travelling electric hoist blocks, for large lamp clusters, and for similar installations.

5. Petroleum Test Methods. Although service performance is the ultimate criterion by which any petroleum product must be judged, there are many physical and chemical laboratory tests which must be conducted and interpreted, to indicate the full-scale performance of a product.

Most of these tests require specialised equipment and the more important of these are discussed in a well-presented 48-page booklet, issued by a leading Petroleum Company under the title "Proving Ground," together with descriptions of how the tests are carried out and the significance which should be attached to the results.

6. Mouldings in Bakelite Materials. A 20-page booklet describes and illustrates the general properties of mouldings made from the more widely used Bakelite phenolic moulding materials, and contains information for the guidance of prospective users and designers.

Examples are given, among others, of heat-, shock-, and water-resistant mouldings, low loss mouldings, acid and alkali-resistant mouldings, impregnated fabrics and papers, and crack-resistant mouldings.

7. Dust Control. The control of dust arising from industrial processes is a problem which is becoming increasingly prominent throughout industry generally, though intensive research and development have resulted in great improvements in all types of equipment in recent years.

In a very neat, illustrated handbook of 72 pages, some of the aspects of dust control are described, particularly in the fields of air cleaning, air filtration, and dust extraction. The underlying fundamental principles are discussed, and additional technical data have been incorporated, together with useful charts, tables, etc., so that the information is presented in a readily accessible reference form.

8. Potentiometers. In a 40-page catalogue, a wide range of potentiometers is described and illustrated. The range includes a series of toroidal precision potentiometers, helical potentiometers, and toroidal heavy-duty ceramic potentiometers, with capacities from 10 to 1000 watts. For use with helical potentiometers, there is a multi-turn indicating dial, designed for both 3-hole and centre hole fixing. The main scale of this dial has 0-100 divisions, and there is a subsidiary scale, reading from 0 to 9, to indicate the turn setting.

9. Electric Cables. A clearly printed, pocket-size 16-page booklet gives comparative sizes, nominal areas, and prices in easy-to-read tabular form of eight ranges of electric cables, all of which conform to the latest British Standards Specifications (1953).

MAIL THIS COUPON TODAY

THE ENGINEERS' DIGEST, 12.53
120, Wigmore Street, London, W.1.

Date.....

Please send free and without obligation the literature indicated by the following circled numbers:

1 2 3 4 5 6 7 8 9

Name .....

Position .....

Company.....

Address .....

Swiss Industries Fair. When the 38th Swiss Industries Fair Basel takes place from 8th to 18th May, 1954, the total exhibition area available will be increased by a new three-storey building which will increase the space for exhibits from roughly 1,000,000 sq. ft. to 1,300,000 sq. ft. next year. There will be 2500 exhibitors as compared with 2200 in previous years, and the Swiss Industries Fair will present an even more extensive display than in previous years.

Jointing Compound for Concrete Runways. A minor problem created by the arrival of the jet plane is how the concrete of airfield runways can be effectively jointed under the new conditions. This has been met by a new expansion jointing compound of which the Air Ministry has now approved, after trying it out on test areas.

These joints open and close seasonally by as much as a quarter of an inch, and up to now a satisfactory expansion joint has been provided by a compound of rubber dissolved in bitumen. This is no longer suitable because not only is the bitumen softened by the fuel spilled from the jet but the effect of the heat and blast from the engines is more serious still. The heat softens the composition and the blast blows it from the joint on to the runway where it lies about as a potential danger to the aircraft using it.

A new composition to meet this new situation has now been developed with a special primer from blends of synthetic resin and rubber, with other plastic materials. This composition keeps elastic both in summer and winter; gives positive adhesion to the concrete; is not affected by jet fuel, and, to a certain extent, keeps out grit. It can be melted at about 150° C to 160° C and poured into the joints without difficulty by the average contracting operative, and its consistency has been safeguarded to give it the correct flow.

The product, Semguard Grade J, which is not too expensive, is made by Semtex Ltd., a Dunlop company, under the protection of patent No. 581,368 and application Nos. 6919/53 and 7122/53.

BRITISH STANDARDS

(*Copies of British Standards may be obtained from the British Standards Institution, 2, Park Street, London, W.1.*)

Dimensions of Fractional Horsepower Motors. B.S. 2048 : 1953 establishes standard dimensions for two frame sizes of motors, these frame sizes being such as will normally cover the following horsepowers at 4-pole speeds, 50 c/s frequency, in drip-proof single-phase capacitor-type continuously rated motors :—

Frame 56 .. $\frac{1}{4}$ to $\frac{1}{2}$ hp.
Frame 66 .. $\frac{1}{2}$ to $\frac{3}{4}$ hp.

The dimensions specified are those necessary to ensure that motors of different makes, and complying with the specification, will be mechanically interchangeable for all normal applications when mounted on the driven machines. With the exception of flange mounting motors, the dimensions specified are identical with those laid down in the corresponding American NEMA standard for general-purpose motors, and so far as those dimensions are concerned, motors complying with B.S. 2048 will also be interchangeable with American motors built to the NEMA Standard.

The new standard is applicable to D.C. motors and to single-phase and polyphase A.C. motors having enclosures of the protected, drip-proof and totally enclosed types. Motor manufactures are not restricted as to their choice of frame sizes for a particular horsepower-speed rating. Price 2/6.

Protective Transformers (B.S. 2046 : 1953) deals with the performance requirements and special characteristics applicable to current and voltage transformers intended for protective purposes in non-balanced protective equipment, and for the operation of earth fault devices with time-lag characteristics.

The standard is divided into three main sections; the first deals with matters which in general are common to both protective current and protective voltage transformers and includes clauses which define the various terms used and specify the nature of the high-voltage tests to be applied. The second and third sections deal more specifically with the requirements relating to current and voltage transformers respectively, e.g. with rated burdens.

The standard also includes appendices which describe, among other matters, the factors to be taken into account in order to determine the rating of a protective transformer, and give examples relating to the over-current rating of current transformers. Particulars are also given of methods of temperature measurement and of the information required by the manufacturer in order to supply transformers to this standard. Figures are included to show methods of terminal marking and the circuit arrangements for measuring the errors of residual voltage transformers. Price 7/6.

Tubular Heat Exchangers for use in the Petroleum Industry (B.S. 2041 : 1953). In view of the international character of the petroleum industry, careful consideration was given to the Standards of the Tubular Exchanger Manufacturers Association of the U.S.A. for R. class heat exchangers because of their use in the petroleum and chemical industries and the advantage of ensuring interchangeability in practice between equipment produced by American and British manufacturers.

The British Standard applies to shell and tube heat exchangers for use in the petroleum industry and covers dimensions and manufacturing requirements peculiar to the tubular heat exchangers. It should also be read in conjunction with B.S. 1500 (Provisional) "Fusion-welded pressure vessels for use in the chemical and allied industries" or any other suitable code which may be specified.

The document is divided into various sections dealing with general requirements, materials, construction and workmanship, scantlings, testing, marking and inspection and testing facilities.

Appendices are included, giving details of materials to be used, dimensions of shell, shell cover and channel flanges as well as pressure temperature ratings for tube plates and flanges.

An appendix gives the information which it is suggested should be supplied by the purchaser or manufacturer as the case may be. Price 12/6.

Acceptance Tests for Turbo-type Compressors and Exhausters (B.S. 2009 : 1953). This standard specifies methods of test for uncooled and cooled axial flow and centrifugal compressors and exhausters, both when the test and guarantee gases are the same and when they are different. It also specifies methods of measurement and deals with the instruments to be used.

It then specifies the method of correcting the test results to allow for the difference between test and guarantee conditions, so as to provide an agreed basis by which guarantees given by manufacturers can be verified, or by which comparisons of the performance can be made.

It also contains a section on definitions and symbols and clauses on permissible deviation, duration of test, induction motor drive, power consumption, and the measurement of pressure, temperature, air flow and speed.

To apply the code it is necessary to know the gas constant and the ratio of the specific heats for the test and guarantee gases. Methods of calculating these quantities for a mixture of gases, illustrated by examples, are given in Appendix A, which also includes a table of constants for a number of gases.

Five detailed examples are given to illustrate the application of the code, and Appendix B, the theoretical basis of the code, explains the basis of the correction factors used.

Charts required for calculations and diagrams of typical test layouts are also included. Price 10/-.

Classified Advertisements.

The rate for all classified advertisements is 6d. per word; in bold print 9d. per word; minimum order 6s. Box number advertisements 1s. extra. Instructions together with remittance must be received not later than the 3rd of each month for advertisements to appear in the same month's issue.

SITUATIONS VACANT

ARMSTRONG SIDDELEY MOTORS Stress Department have vacancies for interesting and important work on gas turbine aero engines. This work covers all aspects of the strength and reliability of the engines and their installations, and is carried out in direct contact with the design and experimental departments. Degree in mathematics or engineering, or HNC or its equivalent required. No experience necessary, but useful experience in design, stressing, experimental or practical work will be taken into account in fixing suitable and progressive salary. Reply to Reference DRE. 3, Personnel Manager, **Armstrong Siddeley Motors,** Coventry.

ASSISTANT CHIEF INSPECTOR (AIRCRAFT). Fully Qualified Inspector required for position as Assistant Chief Inspector for expanding Midlands Company engaged in the manufacture of Aircraft Sheet Metal Details and Assemblies. Should be fully conversant with Ministry procedures. The position offers excellent scope and carries a good salary. Apply in first instance by letter giving full details of previous experience to Ref. EL., Box A121.

AIRCRAFT PLANNING ENGINEER. Fully experienced Planning Engineer required for expanding Midlands Company engaged in the manufacture of Aircraft Sheet Metal Assemblies. The position offers excellent scope for advancement and carries a good salary. Apply in first instance by letter giving full details of previous experience to Ref. EL., Box A122.

JUNIOR DRAUGHTSMAN required for work in connection with Pressure Diecasting Machines and Dies. Machine Tool or General Engineering experience an advantage. Apply giving full details of experience, age and salary required to: Chief Draughtsman, **Wm. Coulthard & Co. Ltd.,** Durranhill Road, Carlisle.

MISCELLANEOUS

RECONDITIONED EX-ARMY HUTS, and many other buildings. Timber, Asbestos, Nissen Type, Hall Type, ... sizes and prices. Write, call or telephone—**Universal Supplies (Belvedere) Ltd.,** Dept. 50, Crabtree Manorway, Belvedere, Kent. Tel.: ERITH 2948.

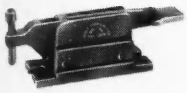
DEODORISERS AND AROMATIC COMPOUNDS for technical and industrial purposes. **Gale & Mount Ltd.,** 3 Rothschild Road, Chiswick, W.4. Phone: CHIswick 6628.

WANTED.—Copies of the March, 1953 issue of "The Engineers' Digest" urgently required. Also Jan., 1949, June, 1950, and Dec., 1951, issues at 3/6 per copy.—Subscription Dept., 120, Wigmore Street, London, W.1.

TRANSLATIONS (Technical, Commercial), all languages. Abstracts also supplied. **Olympia Translation Service,** 149 Blythe Road, London, W.14. RIVerside 5135.

REDUCE TOOLING COSTS!

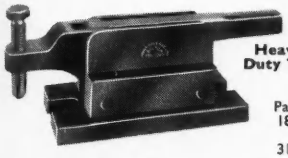
'Holtite' Clamp (Open)



Closed Position

with the **'HOLTITE'** *Versatile Method of Clamping.*

Saves loading time on Drilling, Milling, Shaping, etc. Widely adapted to JIGS & FIXTURES. Saves endless time on Production Work.



Heavy Duty Type

Pat. Nos. 18747/51 and 31645/52

CAN WE HELP YOU?

Write for Full Details to:—

JAMES HOLT ENGs. LTD.

LIVSEY COURT ENG. WORKS—CHINA LANE

HIGHER BRIDGE STREET, BOLTON

Phone: BOLTON 1209

For Optimum Hardness and Strength

Nitrided NITRALLOY STEEL

Particulars from

NITRALLOY LIMITED

25, TAPTONVILLE ROAD, SHEFFIELD 10

Telephone: 60689 Sheffield

Telegrams: Nitralloy Sheffield

INDUSTRIAL CLEANING *with a* CURRAN UNIT

is the speediest way to greater and better production with an economy in labour and running costs. There is a CURRAN unit for every industrial washing purpose—for large or small components. Write now for details to:—

The model illustrated above is a special purpose machine with positioned jets to wash large castings or machined parts such as rear axles, etc.

EDWARD CURRAN ENGINEERING LTD
PROCESS PLANT DIVISION · CARDIFF
TELEPHONE: CARDIFF 28611

B.O.C ARGONAUT for continuous welds on Aluminium, Stainless Steel and Bronze*...

* IN ANY POSITION

* WITH AUTOMATIC ELECTRODE FEED

* AND SELF-STABILISING ARC

The gun, with casing for the shielding gas, wire feed and welding cables attached. The gas nozzle is quickly detachable for replacement of the copper contact tube through which the electrode is fed to the work.

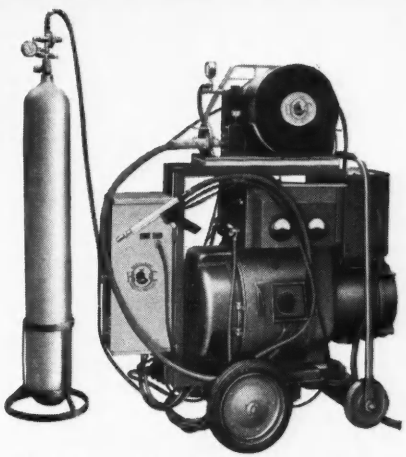
ASK YOUR NEAREST B.O.C BRANCH FOR FULL DETAILS

The simplicity and convenience of the Argonaut gun is well shown in this picture, where the operator is welding in the overhead position.

This new process is vitally important to all firms concerned with quantity welding on aluminium and other light alloys, stainless steels and bronze, and the welding together of *different* metals, in plate from $\frac{3}{16}$" up to any thickness.

Our leaflet will tell you:

- how the electrode wire is fed automatically to the torch nozzle
- why no flux is required
- how the argon shielded arc is self-compensating for irregular torch movements
- how this speedy process welds up to 1-inch thickness in one or two passes
- how relatively unskilled operators can achieve high quality welds in vertical and overhead positions

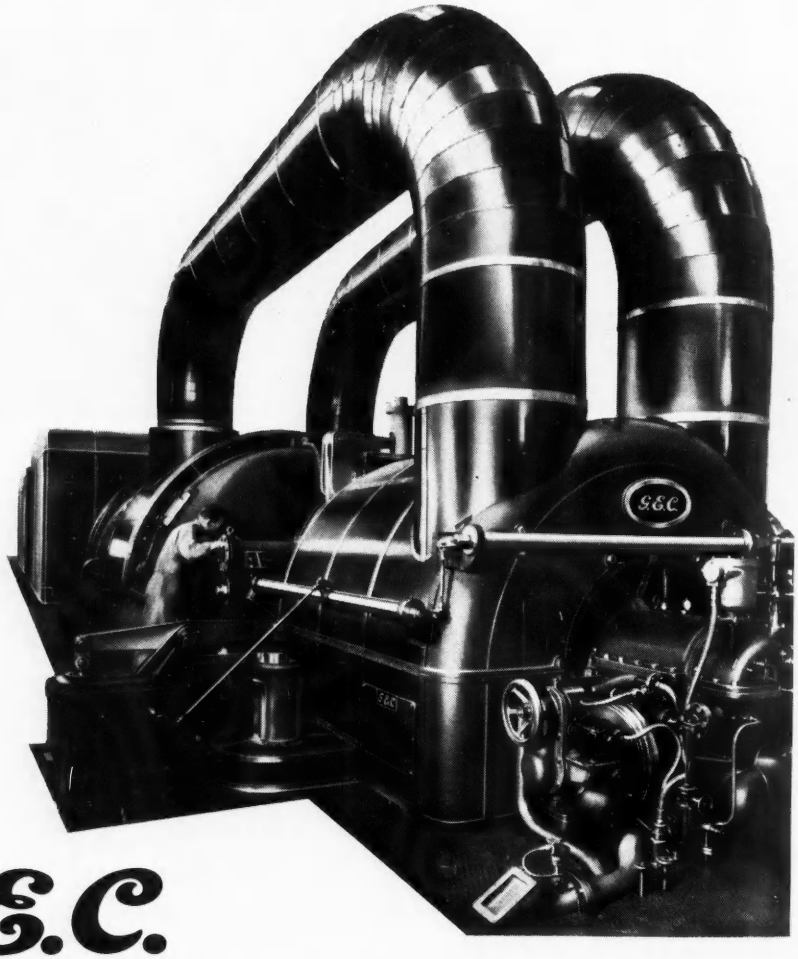


The Argonaut unit complete with associated equipment including a D.C. generator, contactor, gun and Argon cylinder.

BOC **THE BRITISH OXYGEN CO LTD**

LONDON & BRANCHES

New world efficiency record



by G.E.C.

The 60,000 kW hydrogen-cooled turbo-alternators recently installed at Uskmouth Power Station, Newport, Mon., are achieving the highest efficiency ever known for power generators of this size operating at a steam pressure of 900 lb. per sq. in. and at a steam temperature of 900° F.

The heat consumption figure at full output officially confirmed by the British Electricity Authority is 9,027 B.Th.U. per kWh.

THE GENERAL ELECTRIC CO. LTD., MAGNET HOUSE, KINGSWAY, LONDON, W.C.2

EFFICIENT AIR MOVEMENT

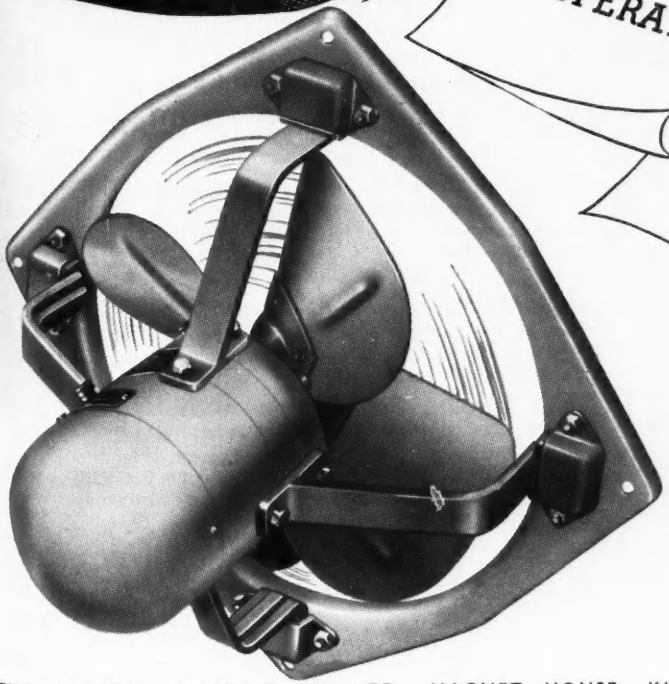
LOW POWER CONSUMPTION

G.E.C. PROPELLER FANS FOR RELIABLE PERFORMANCE

EASY INSTALLATION

QUIET IN OPERATION

STURDILY BUILT



The range of G.E.C. Propeller Fans is varied and comprehensive. This 12" model displaces air more quietly and at less cost than fan with narrow or flat blades. Air movement 1120 c.f.m. at 1350 r.p.m. For full details send for publication V 968.

THE GENERAL ELECTRIC CO. LTD., MAGNET HOUSE, KINGSWAY, LONDON, W.C.2.

With expansion of production facilities

DUNLOP *Flame-proof* BELTING

IS NOW REACHING THE PITS IN INCREASING QUANTITIES

N·C·B No 3 APPROVAL

BELT CODE 512/2 & 3 . Medium Heavyweight 56 oz. Fabric
This belting is of patent construction and incorporates medium heavyweight fabric. The two-ply construction is ideal for face and gate use, while belts made of a greater number of plies are available for longer hauls.

N·C·B No 4 APPROVAL

BELT CODE 512/4 & 5 . Standard 32 oz. Fabric
This belting is of conventional construction and is made of special compounds, which provide flexible five or six-ply belts which are suitable for face, gate and trunk installations.

N·C·B No 5 APPROVAL

BELT CODE 512/1 . Heavyweight 135 oz. Fabric
This belt with the super-strength heavyweight fabric of patent design is of single ply construction and has been developed to give maximum flexibility. Under conditions of confined space where small size driving and terminal drums are used this belt offers exceptional service.

DUNLOP RUBBER CO. LTD., (G.R.G. DIVISION), CAMBRIDGE STREET, MANCHESTER, 1. CENTRAL 2131

LONDON:	Clerkenwell House, Clerkenwell Green, London, E.C.1	Clerkenwell 3871
BIRMINGHAM:	Dunlop House, Livery Street, Birmingham, 3	Central 8585
LEEDS:	Buckton's Chambers, 57 Meadow Road, Leeds, 11	Leeds 34091
GLASGOW:	Dunlop Rubber Co. (Scotland) Ltd., North Wallace Street, Glasgow, C.4	Bell 3411

3G·GM4·C

looking for a fly in the ointment . . .

People in industry are getting particular. Whichever way you turn, you find them looking for the fly in the ointment, or seeking the nigger in the woodpile, or even looking gift horses in the mouth—peering not only *at* things but *into* them and *through* them. For this sort of poking and prying, those who are really up to date rely increasingly on radiography—aided and abetted, of course, by ILFORD Industrial X-ray films. The new ILFORD booklet "X-ray Films, Screens, and Chemicals for Industrial Radiography," is a treatise in miniature on this important branch of non-destructive testing. Write for a free copy today.

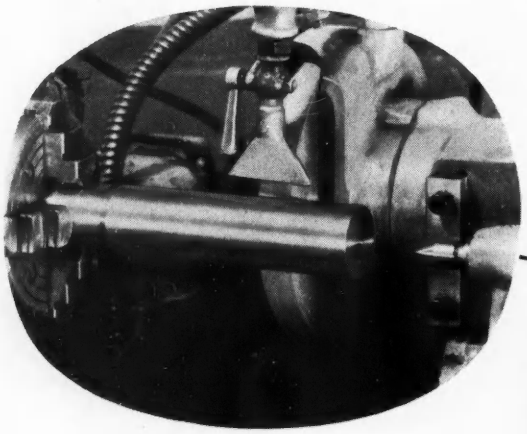
ILFORD

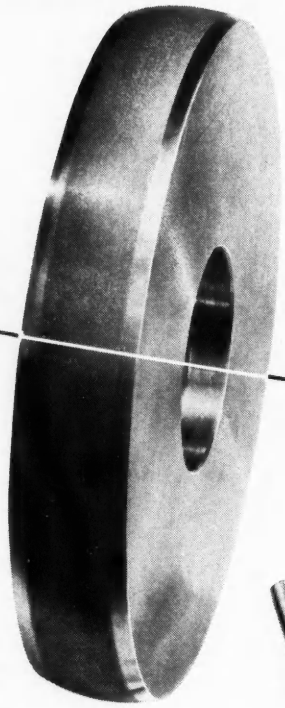
Industrial X-ray films

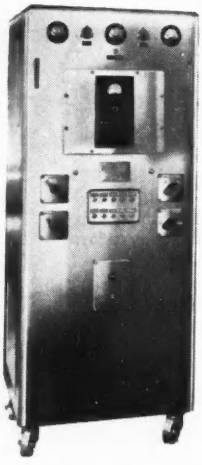
in the service of Industry

ILFORD LIMITED · ILFORD · LONDON

SPARKS
ARE THE BEST FORM GRINDERS







Spark machining has shown phenomenal savings in many tool room applications using semi-skilled labour. If your problem is complicated shapes and hard-to-machine materials it would interest you to see our demonstration equipment put to a test on your own particular machining, die-sinking or piercing operation.

SPARCATRON

TUFFLEY CRESCENT · GLOUCESTER

Sparcatron spark machining methods and apparatus are fully protected by British and foreign patents.

Telephone: Gloucester 21164 (3 Lines)

Sole licensees in the United Kingdom: **IMPREGNATED DIAMOND PRODUCTS LIMITED · GLOUCESTER**

J.W.

SWISS

ROCH-ETALON

The Highest Quality Precision Measuring Instruments Available

- VERNIER CALIPERS of all types and sizes up to 15 feet
- VERNIER DEPTH GAUGES
- VERNIER HEIGHT GAUGES
- GEAR TOOTH CALIPERS
- MICROMETERS — 23c Type Full Range from 0-1 in. to 11 in.-12 in.
- DIAL INDICATORS
- BEVEL PROTRACTORS

MADE IN STAINLESS STEEL ONLY

LARGE STOCKS IN LONDON

■ PRISMATICALLY ENGRAVED ■
■ TUNGSTEN CARBIDE TIPPED ■

ALEXANDER S. NEWALL Machine Tool Co., Ltd.

Phone : Hampstead 3855

287 FINCHLEY ROAD, LONDON, N.W.3

Who never lose a customer—COMPETITIVE IN QUALITY - PRICE - DELIVERY

SOLE IMPORTERS FOR THE UNITED KINGDOM

SOLE DISTRIBUTORS FOR SCOTLAND :—

B. ARTHUR HEMS LTD.,
80-82 YORK STREET,
GLASGOW, C.12

Telephone: CENTRAL 4287/9

GET MORE
out of your machines

Use DORMER

THE SHEFFIELD TWIST DRILL AND STEEL COMPANY LIMITED

SHEFFIELD · ENGLAND PHONE: 24137 (5 LINES) GRAMS: PROELLS · SHEFFIELD

LONDON OFFICE: TERMINAL HOUSE, LOWER BELGRAVE STREET, S.W.1 · Phone: SLOANE 2111 (4 lines) · Grams: PROELLS KNIGHTS LONDON

DORMER TOOLS ARE OBTAINABLE FROM YOUR USUAL ENGINEERS' MERCHANTS

HE'S MAKING STUD WELD HISTORY

with the newest, best and cheapest stud gun on the market

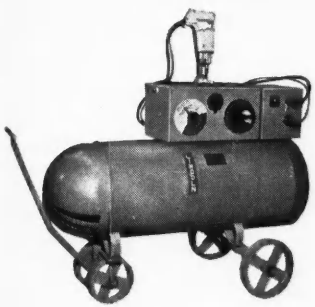
Always way out in front on all welding equipment, LINCOLN have perfected a stud gun that puts stud welding in a new light from every point of view—economy, reliability, durability, simplicity.

It is by far the cheapest obtainable. It eliminates the complications of electronic timing. Designed on simple mechanical principles, it is reliable and robust. Once set, it repeats indefinitely with perfect precision every time.

Approved by the Ministry of Supply for studding armour-plate, this revolutionary LINCOLN Stud Gun can confidently be recommended for *all* stud welding.

***It costs* £135**

★ NOTE THESE LINCOLN ADVANTAGES



- Hydraulic timing unit directly controls stud movement and duration of welding arc.
- The hydraulic unit is in a completely sealed system: no glands or joints to leak operating fluid or allow in dirt or grit.
- Spring-loaded foot retracts on pressure and may be locked in any position.
- The Lincoln ferrule is used for all weld positions and provides a neat collar at the base of the stud.
- No fluxing of studs required.
- No alteration of setting needed to change from downhand, vertical or overhead welding.

This new gun will operate with any standard Lincoln Motor Generator. For instance the Lincoln SAE.300 will deposit studs from $\frac{3}{16}$" to $\frac{3}{4}$", whilst the Lincoln SAE.400 enables a range of studs from $\frac{3}{16}$" to $\frac{1}{2}$" to be deposited. The Lincoln SAE.600 increases the range to $\frac{5}{8}$".

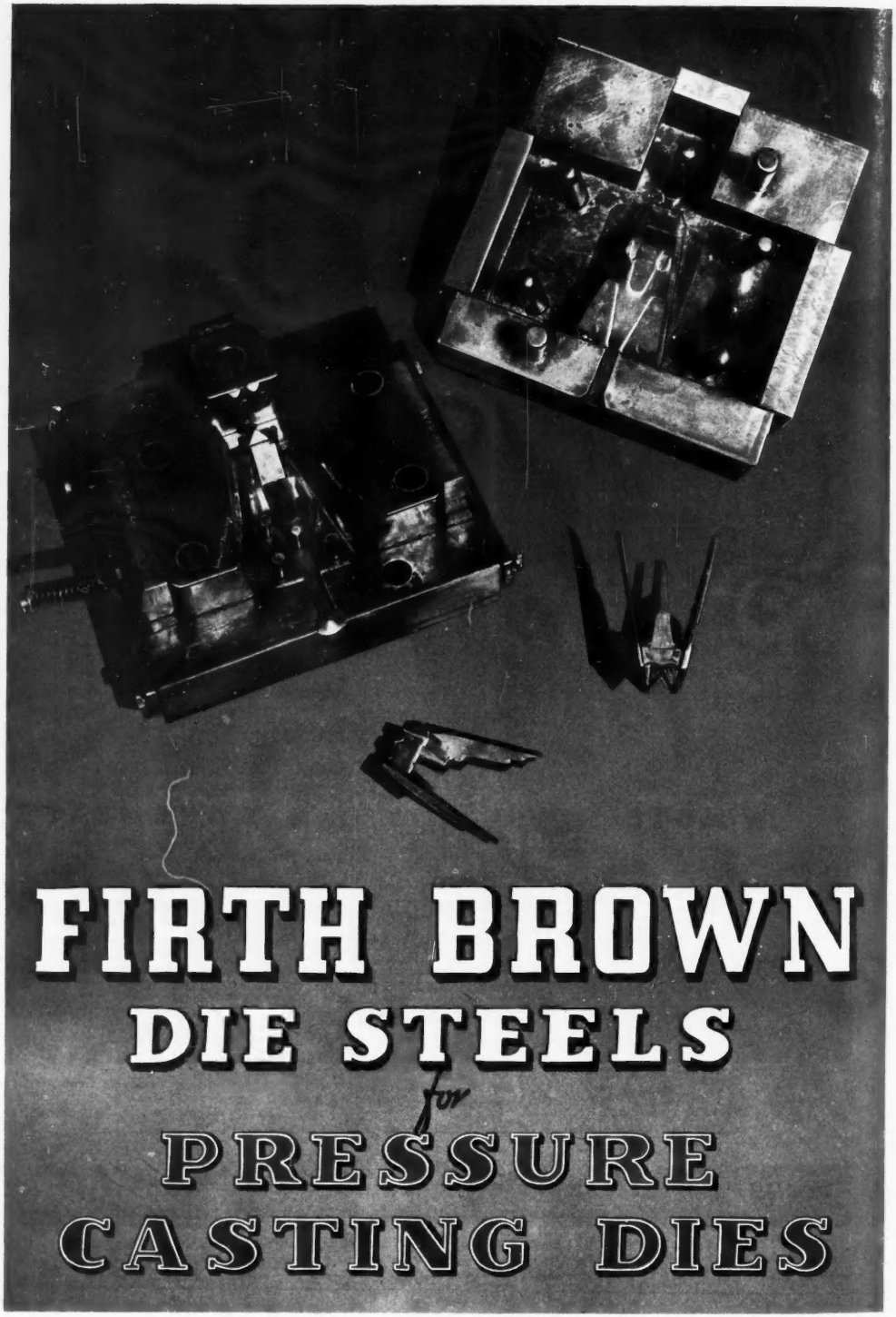
LINCOLN

Ask to see this new Lincoln Stud gun demonstrated

Free brochure on the Lincoln Stud gun is now available, write to Dept. C.

LINCOLN ELECTRIC CO LTD · WELWYN GARDEN CITY · HERTS · WELWYN GARDEN 920

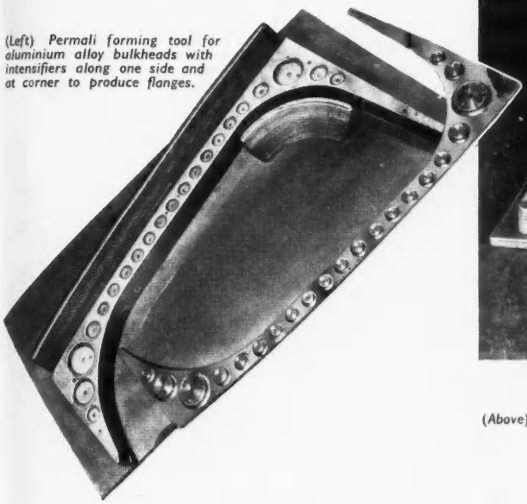
SG1



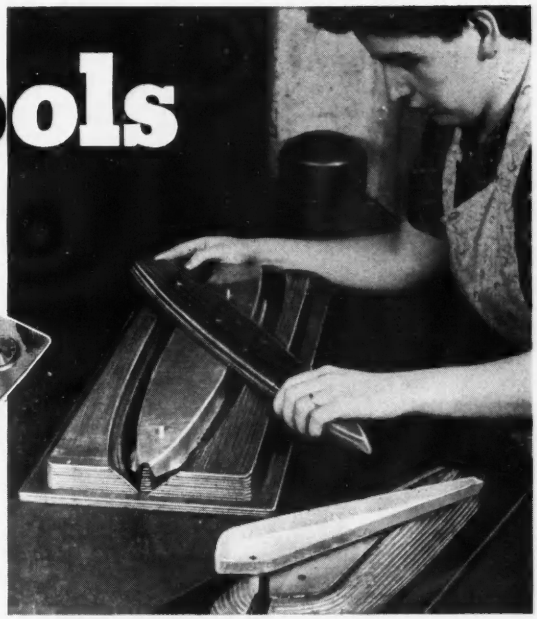
Issued by Thos. Firth & John Brown Ltd., Sheffield

Press tools

for rubber die presses etc.



(Left) Permali forming tool for aluminium alloy bulkheads with intensifiers along one side and at corner to produce flanges.



(Above) A girl operator removing formed parts from a Permali rib-forming tool.

. . . are best made of PERMALI

BECAUSE they are easily and rapidly machined (and therefore, LOW in COST), non-chipping, hard-wearing, light yet strong, and easily handled by women operators.

For full details, write for leaflet BK.93 to

PERMALI LIMITED

GLOUCESTER, ENGLAND. TEL. 24921.

Manufacturers of :— Permali Laminated Insulating Materials and Components — Staywire Insulators — Railway Insulating Fishplates — Dielectric Studs and Nuts — S.R.B.P. Tubes, H.V. Bushings and Terminals.

Offices in London, Manchester, Birmingham and Overseas.

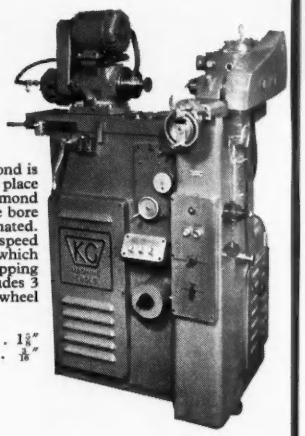
PERMALI IS

a densified wood laminate combining mechanical and dielectric strength, easy machineability and dimensional stability; with resistance to heat, chemicals, weathering and abrasion.

Other general engineering applications include:—

BEATING BLOCKS
INSULATING STUDS AND NUTS
SPINNING CHUCKS
FOUNDRY PATTERNS
FILTER PLATES
AND FABRICATED ASSEMBLIES WITH RESISTANCE TO CHEMICALS

precision internal grinding



High outputs and close accuracy coupled with simplicity of control and ease of operation make the Keighley Internal Grinding Machine equally suitable for tool room or production shop. The diamond is pre-set so that the wheel-truing takes place prior to the finishing cut, thus the diamond itself regulates the finished size of the bore and intermediate gauging is eliminated. The workhead has 6 speeds and the 4-speed gearbox provides the table speeds which are individually available without stopping the machine. Extra equipment includes 3 or 4-jaw chucks and attachments for wheel forming

MAX. DIA. Ground . . . . . $1\frac{3}{8}$"
MIN. DIA. Ground . . . . . $\frac{3}{16}$"

Early delivery of this machine can be given

A PRODUCT OF KEIGHLEY GRINDERS (MACHINE TOOLS) LTD., KEIGHLEY

Photograph by permission of E M O Instrumentations Ltd., Colnbrook.

model KSE internal grinding machine

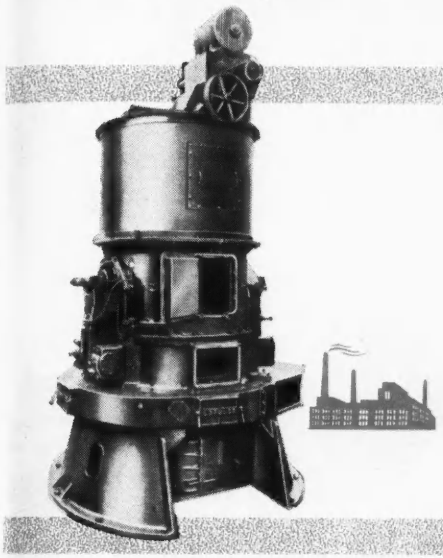
NEWALL GROUP SALES LTD., PETERBOROUGH

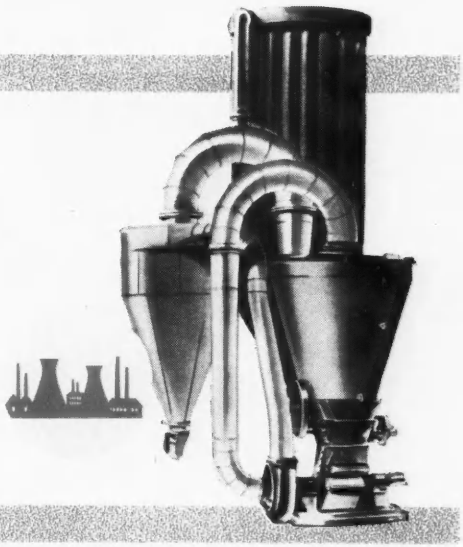
PHONE: PETERBOROUGH 3227-8-9 *TELEGRAMS: PRECISION PETERBOROUGH.*

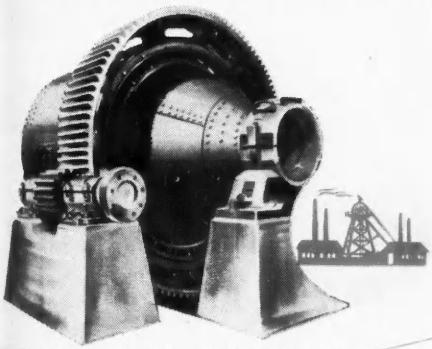
SCOTTISH AGENTS: DRUMMOND ASQUITH LIMITED, 175 WEST GEORGE STREET, GLASGOW C.2

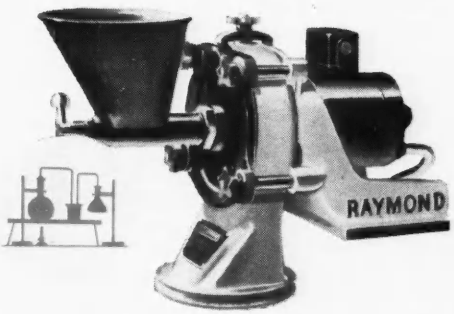
P.3173

ICL *experience** COUNTS









* With the widest range of milling plant, grinding the greatest variety of materials.

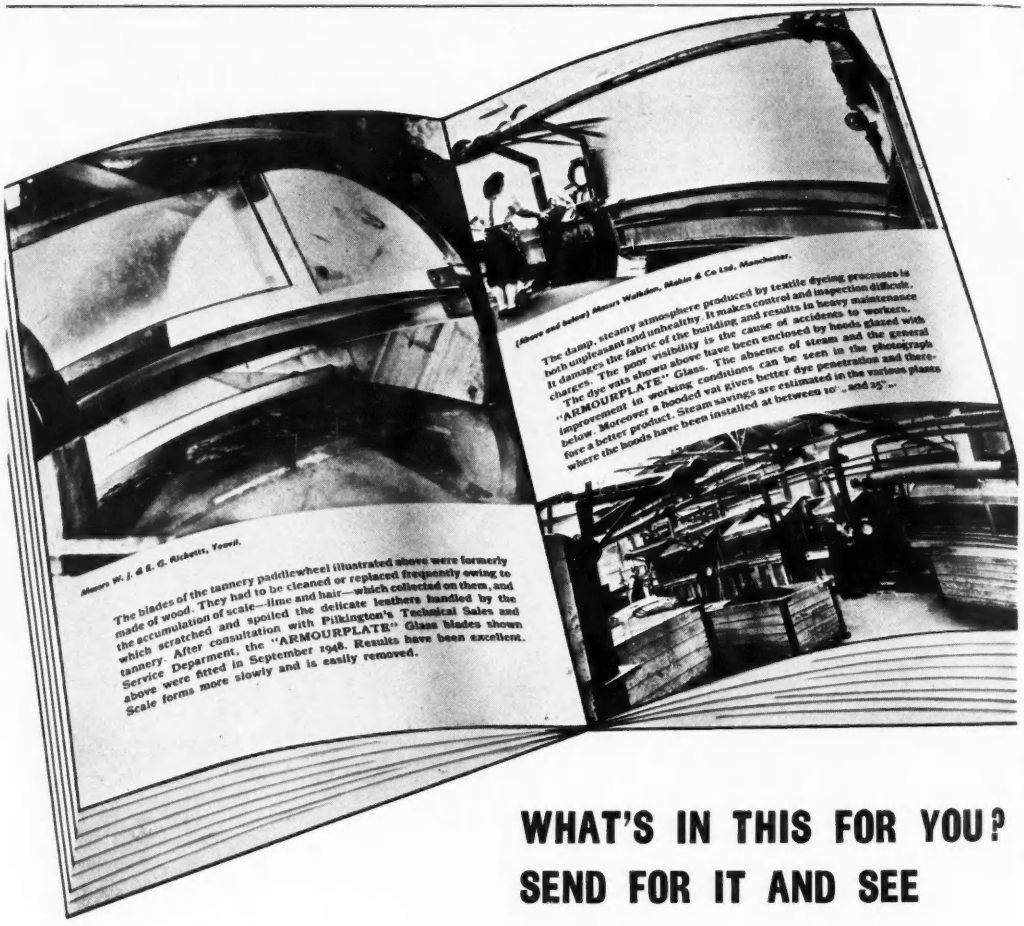
High Speed : Medium Speed : Low Speed

ICL mills grind materials as widely varied as coal or carborundum, soapstone or silica, at the rate of hundreds of tons or hundreds of grams per hour. ICL's experience ensures expert advice on any grinding problem.

INTERNATIONAL COMBUSTION LIMITED

LONDON OFFICE: NINETEEN WOBURN PLACE, W.C.1
WORKS: DERBY, ENGLAND; PORT ELIZABETH, SOUTH AFRICA; SYDNEY, AUSTRALIA.

The Place of Glass in Industry . . . . . .



Messrs W. J. & E. G. Ricketts, Yeovil.

The blades of the tannery paddlewheel illustrated above were formerly made of wood. They had to be cleaned or replaced frequently owing to the accumulation of scale—lime and hair—which collected on them, and which scratched and spoiled the delicate leathers handled by the tannery. After consultation with Pilkington's Technical Sales and Service Department, the "ARMOURPLATE" Glass blades shown above were fitted in September 1948. Results have been excellent. Scale forms more slowly and is easily removed.

(Above and below) Messrs Watkden, Mahin & Co Ltd, Manchester.

The damp, steamy atmosphere produced by textile dyeing processes is both unpleasant and unhealthy. It makes control and inspection difficult. It damages the fabric of the building and results in heavy maintenance charges. The poor visibility is the cause of accidents to workers. The dye vats shown above have been enclosed by hoods glazed with "ARMOURPLATE" Glass. The absence of steam and the general improvement in working conditions can be seen in the photograph below. Moreover a hooded vat gives better dye penetration and therefore a better product. Steam savings are estimated in the various plants where the hoods have been installed at between 10" and 25"..

WHAT'S IN THIS FOR YOU? SEND FOR IT AND SEE

Glass today does many more jobs in buildings and industrial plant than filling windows. To its basic properties of transparency and translucency are added its powers of giving protection, insulation and resistance to impact, thermal shock, and chemical corrosion.

We have published some case histories in the booklet 'The Place of Glass in Industry', a copy of which we will gladly send to you.

Our Technical Sales and Service Department at St. Helens, is always available to help you with your problems.

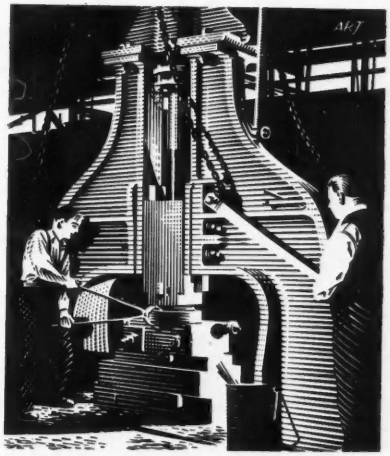
Glass supplies are available through the usual trade channels.

PILKINGTON BROTHERS LIMITED

St. Helens, Lancs., and Selwyn House, Cleveland Row, St. James's, London S.W.1

Telephones: St. Helens 4001, Whitehall 5672-6

I.3



What will a purchasing agent pay —for Tradition?

If by Tradition you mean nothing but a perpetual harking back to old-fashioned ways and the Chairman's great-grandfather, then the answer is—Nothing!

But even the toughest buyer knows that there is value in dealing with a firm of individuality and character despite the fact that it was founded in 1778.

The 1500 workers at Doncasters of Sheffield embody old skills informed and transformed by scientific knowledge of materials and treatment and applied to the output of modern plant of high productivity.

Doncasters supply largely to buyers in the transport and engineering trades who have a need for drop forgings, valve stampings, bars of tool or other tough hard steels, and steel forgings both light and heavy.

Such men buy keenly, but not so keenly that they do not value high quality, service and integrity of craftsmanship.

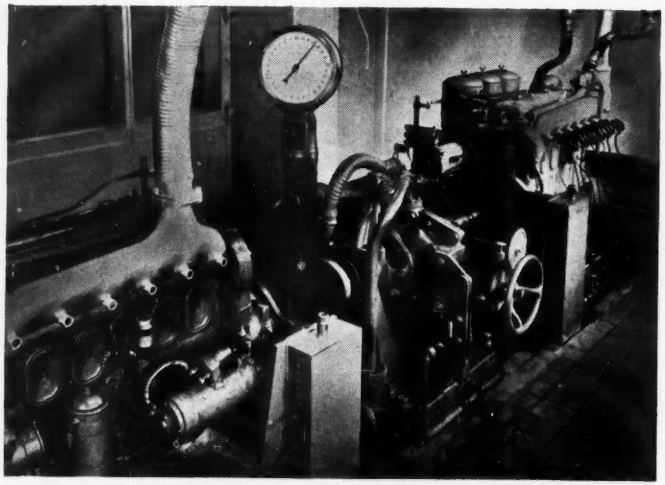
DONCASTERS ◇ *1778* D D

DANIEL DONCASTER & SONS LIMITED · SHEFFIELD

FORGINGS · DROP FORGINGS · HARDENED STEEL ROLLS · HEAT TREATMENT

◇ D D

P11



FROUDE

HYDRAULIC DYNAMOMETERS

are made in a wide range of sizes from small Dynamometers to complete Engine Test House equipment.

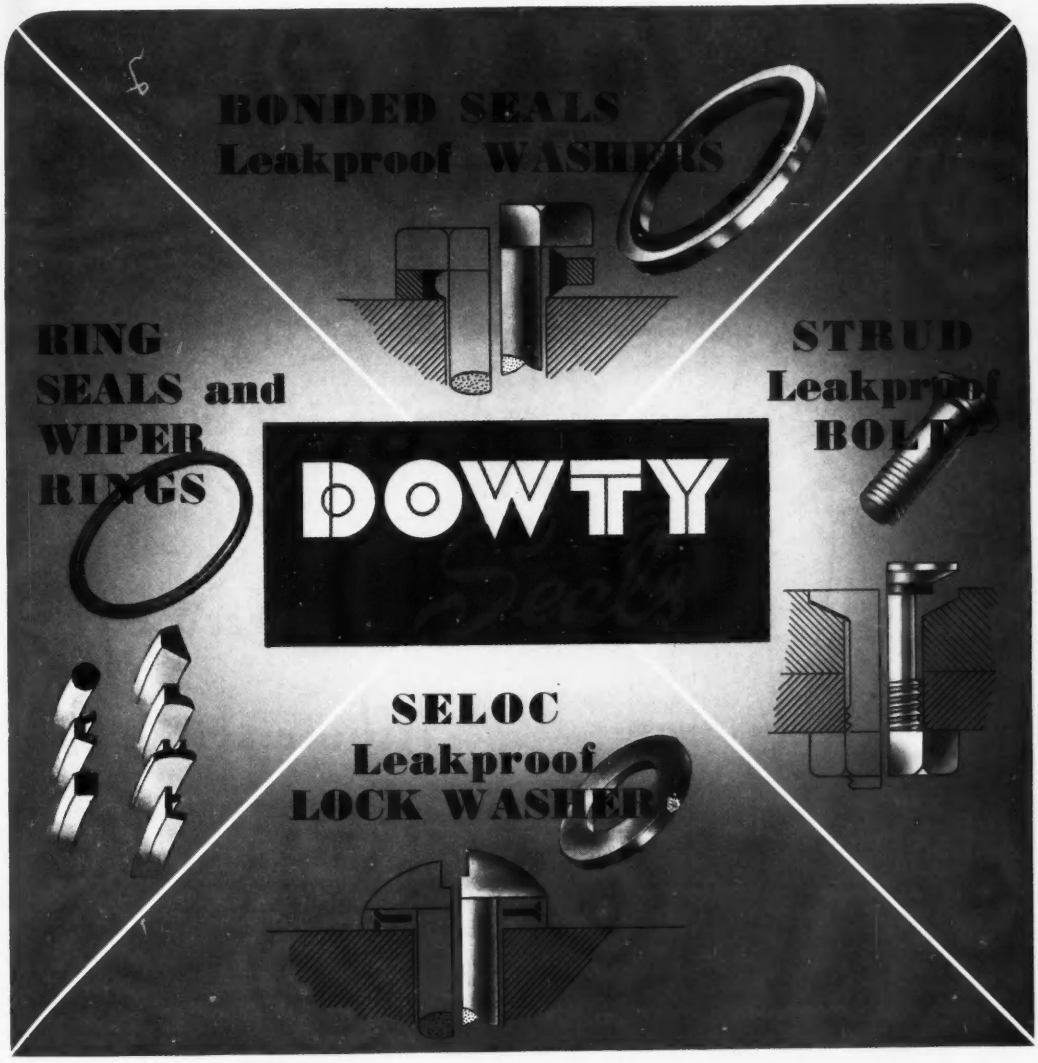
A lifetime's experience has brought improvements and refinements which make our products the accepted standard of B.H.P. measurement.

Illustration shows a Froude Dynamometer at the works of Messrs. Mackay Industrial Equipment Ltd.

(The names 'Heenan' and 'Froude' are Registered Trade Marks of the Company).

HEENAN & FROUDE LIMITED

WORCESTER ENGLAND



# of all types . . .
. . . for all purposes

BONDED SEALS. A metal washer permanently bonded to a rubber ring—provides an efficient and foolproof answer to innumerable sealing problems. Wide applicability is catered for by an extensive range of dimensions and, dependent on size, the ability to withstand pressures up to 10,000 lbs./sq. in.

STRUD. Provides a leakproof and flush-fitting fixing method for use in the fabrication of pressure vessels—a rubber ring is bonded to a wide countersunk headed bolt. When tightened with a nut a sealing layer of rubber is formed between bolt head and hole. Dimensions to suit requirements.

SELOC. By moulding a "shakeproof" washer within a rubber sheath, the functions of both a seal and a locking medium are combined together with the additional features of protection against under head corrosion. Either internal or external toothed types are available in all standard sizes.

O, U & □ SECTION RING SEALS. Available in either synthetic, natural or silicone rubber for use with gases or liquids, acids or alkalis. These sealing rings are suitable for a wide variety of static or dynamic applications at high or low temperatures in a very wide range of sizes.

DOWTY SEALS LIMITED · ASHCHURCH · GLOS · ENGLAND

A boring bar in need of lubrication . . .

. . . stood deserted save for the machine shop foreman crying into his empty glass. " How can I stop my machines breaking down ? " he sobbed. The barmaid glumly surveyed the row of bottles he had emptied. " You may not be an authority on machinery," she observed, " but you are certainly an authority on lubrication ! " A wild light of hope appeared in the foreman's eye. " That's it," he shouted, " authority on lubrication . . . Tecalemit . . . AUTOMATIC LUBRICATION ! " He fled from the room. " Well," complained the barmaid, " perhaps, in future, he'll have the grease to say goodbye ! "

Tecalemit lubrication systems—fully automatic, semi-automatic or manually operated—feed every bearing with the correct amount of oil or grease at the correct intervals of time, regularly . . . unfailingly . . . efficiently. A Tecalemit engineer will gladly call to discuss your particular lubricating problems with you.

TECALEMIT

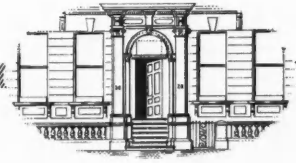
The Authority on Lubrication

PLYMOUTH, ENGLAND

1401

G6

The almost bewildering variety of flexible tubing may seem to be a maze—but there is a simple way out. You can walk into our London Showrooms and see hundreds of samples and installation photographs of every kind of flexible tubing and hose—*an entirely new service to industry*. Our experience as makers and suppliers is at your disposal ; let us help you choose the best 'flexible' for the job—at the right price. If you prefer, our representative can call and talk things over personally.



If there is a 'flexible' answer-you'll find it at

26 Grosvenor Gardens, S.W.1

'Phone: SLOANE 6185 (3 lines) or 5109 (2 lines)

Compoflex

FLEXIBLE TUBING & HOSES

Compoflex Company Limited. Factories at Diggle near Oldham and South Wimbledon.

Write now for

"Compoflex Flexible Tubing & Hoses"

our new descriptive brochure which includes

GAS AND AIR HOSE · SUCTION AND DELIVERY HOSE · METALLIC FLEXIBLES · RUBBER FLEXIBLES SPECIALS · FITTINGS & COUPLINGS · COMPOTAPE

G 68

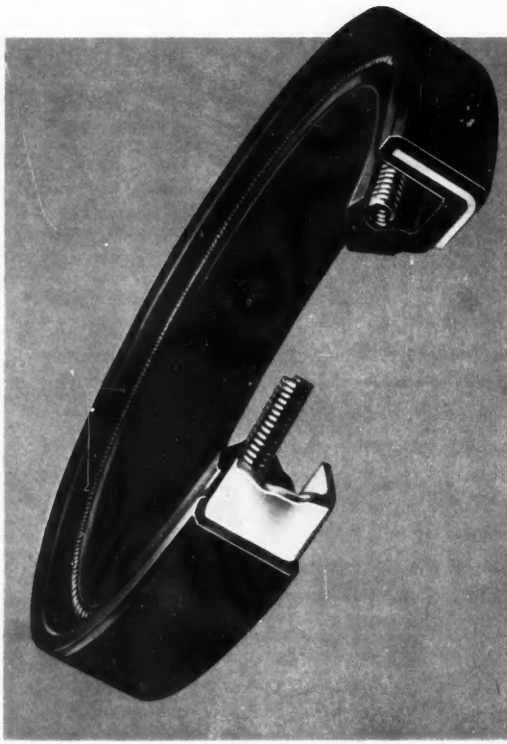
GACO

REGD. TRADE MARK

THE GACO M.I. OIL SEAL

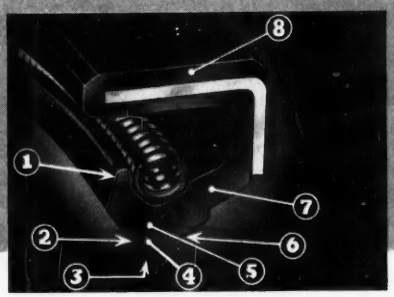
British Patent No. 479743

The Scientifically Designed Oil Seal for Rotary Shafts. A Gaco Product.



1. Deep rim affords perfect Spring Retention.
2. Large Face Angle brings Sealing Edge well below spring.
3. Knife edge Contact at Sealing Point.
4. Sealing Point stiffened against local deformation by large included angle.
5. This section stiffened to prevent deformation under load.
6. Shaft angle gives adequate clearance.
7. Flexible Web.
8. Gaco Skin affords better fluid tight fit in Housing.

"HAIRLINE" LIP CONTACT!

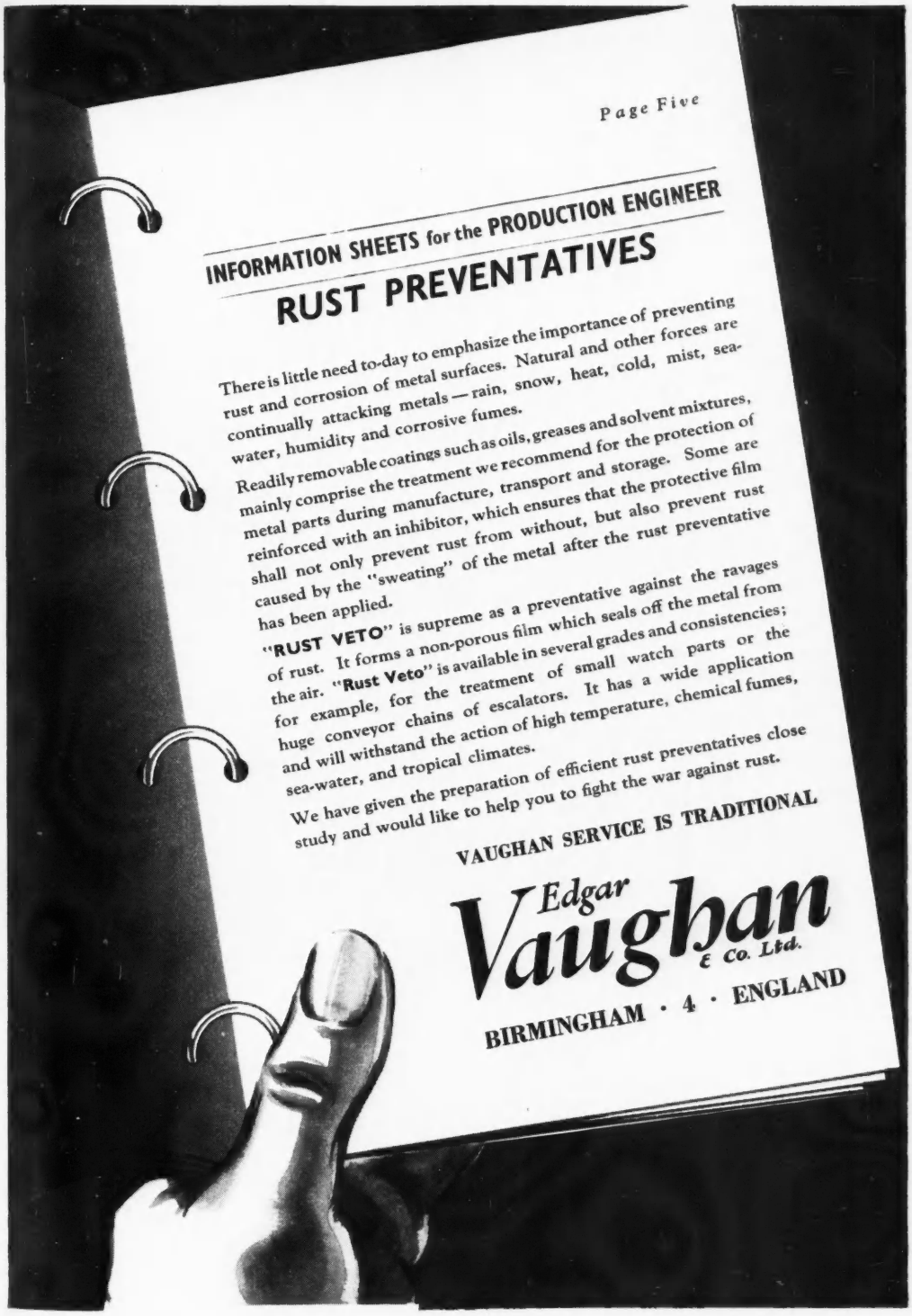


ANGUS OIL SEALS

GEORGE ANGUS & Co LTD

FLUID SEALING ENGINEERS

NEWCASTLE UPON TYNE, 6

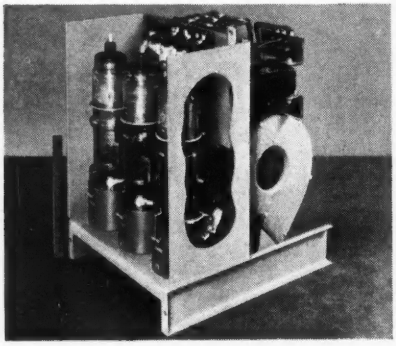

Page Five
INFORMATION SHEETS for the PRODUCTION ENGINEER
RUST PREVENTATIVES
There is little need to-day to emphasize the importance of preventing rust and corrosion of metal surfaces. Natural and other forces are continually attacking metals — rain, snow, heat, cold, mist, sea-water, humidity and corrosive fumes.
Readily removable coatings such as oils, greases and solvent mixtures, mainly comprise the treatment we recommend for the protection of metal parts during manufacture, transport and storage. Some are reinforced with an inhibitor, which ensures that the protective film shall not only prevent rust from without, but also prevent rust caused by the "sweating" of the metal after the rust preventative has been applied.
"RUST VETO" is supreme as a preventative against the ravages of rust. It forms a non-porous film which seals off the metal from the air. "Rust Veto" is available in several grades and consistencies; for example, for the treatment of small watch parts or the huge conveyor chains of escalators. It has a wide application and will withstand the action of high temperature, chemical fumes, sea-water, and tropical climates.
We have given the preparation of efficient rust preventatives close study and would like to help you to fight the war against rust.
VAUGHAN SERVICE IS TRADITIONAL
Edgar Vaughan & Co. Ltd.
BIRMINGHAM · 4 · ENGLAND

Medium voltage industrial excitrons

'ENGLISH ELECTRIC' excitrons are suitable for a wide range of rectifier applications because they are robust, compact and combine high converting efficiency with long service life.

Illustrated is a standard 100 amp. industrial rectifier for operation at 600 volts D.C. maximum. The unit incorporates three type A.R.62 excitrons on a withdrawable chassis. A standard 200 amp. unit is also available, having six excitrons on two chassis.

'ENGLISH ELECTRIC' excitrons are supplied as complete rectifier equipments, or on the standard three-tube chassis shown, also as loose tubes.



'ENGLISH ELECTRIC'

excitrons

THE ENGLISH ELECTRIC COMPANY LIMITED, QUEENS HOUSE, KINGSWAY, LONDON. W.C.2

Rectifier Sub-station Department, Stafford

WORKS: STAFFORD · PRESTON · RUGBY · BRADFORD · LIVERPOOL · ACCRINGTON

IG.2

PRESENTING THE **CINCINNATI** RANGE OF

BRITISH BUILT MACHINE TOOLS

TOOLROOM AND GENERAL PURPOSE MILLING MACHINES

PRODUCTION MILLING MACHINES

TOOL & CUTTER GRINDING MACHINES

DIE-SINKING MACHINES

SURFACE BROACHING MACHINES

CENTRELESS GRINDING MACHINES

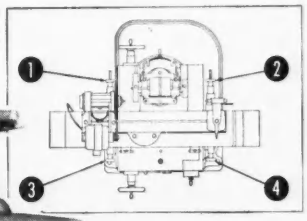
CINCINNATI

ESSENTIAL EQUIPMENT for EVERY MACHINE SHOP . . .

THE CINCINNATI NO. 2 TOOL & CUTTER GRINDER

offers exceptional flexibility in sharpening a wide variety of cutting tools.

Attachments for cylindrical internal and surface grinding

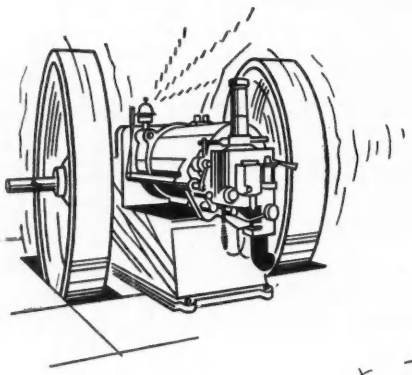


Note the 4 - Point Operational Control

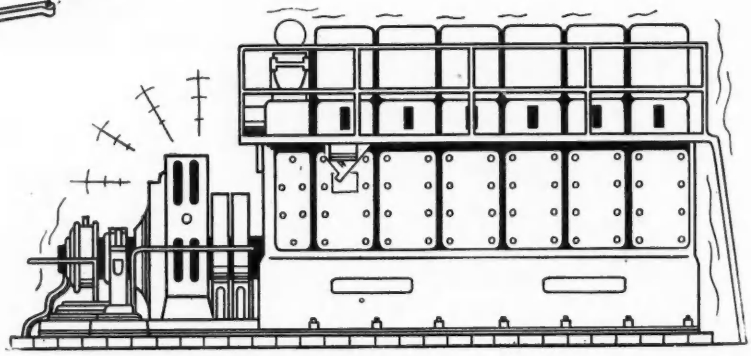
Full specifications are given in Bulletin M.1618-E.

CINCINNATI MILLING MACHINES LIMITED • BIRMINGHAM 24

FASHIONS CHANGE



WITH AGE AND RACE–



BUT BRASS CONTINUES TO HOLD ITS PLACE

. . . particularly the fine quality products of James Booth including:—

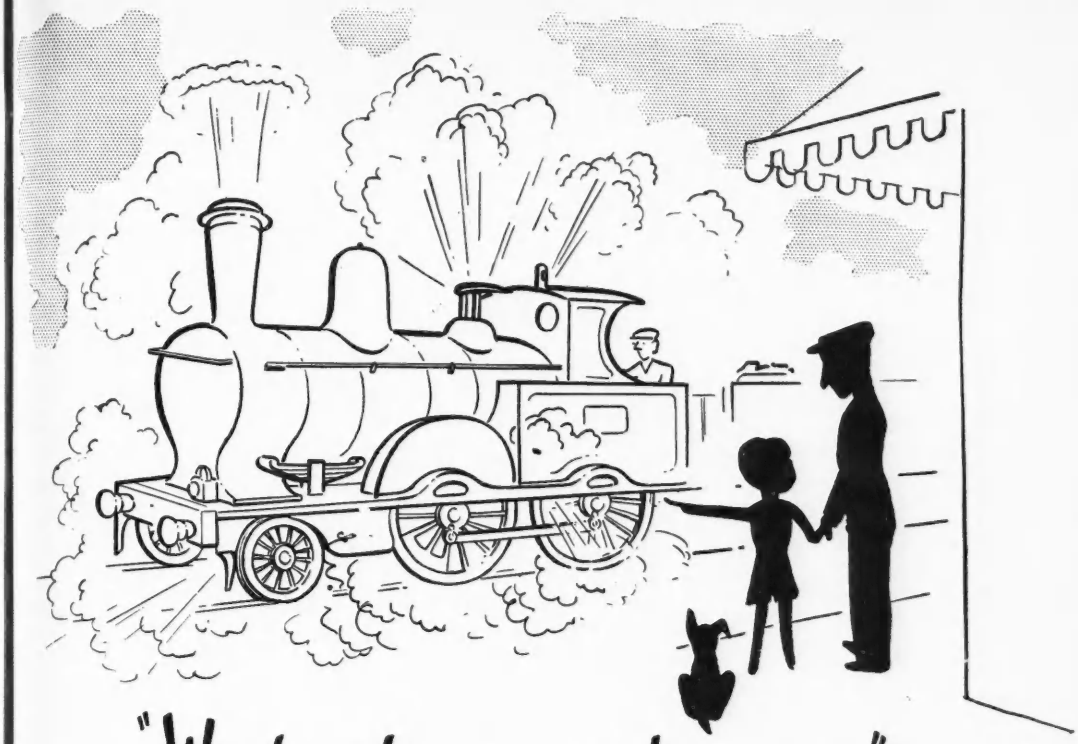
Seamless Drawn Tubes
Extruded Rods & Sections
Rolled Sheet & Strip
Formed Strip Sections
Drawn Strip & Wire
Large Forgings
Condenser Tubes
Domestic Water Service Tubing

James Booth

AND COMPANY LIMITED

BOOTH BIRMINGHAM

ARGYLE STREET WORKS · NECHELLS · BIRMINGHAM 7 · TELEPHONE: EAST 1521

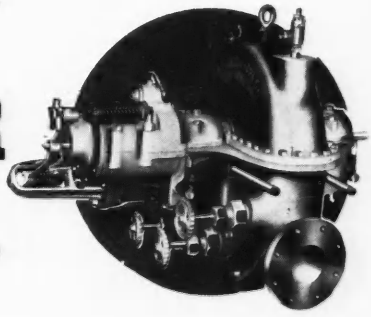


"Waste steam...waste money"

murmured Algernon

One day young Algernon saw an engine let off steam. "Why" he asked "did it do that?" "Because" said his father, "it had too much". "Then why don't they do something with it?" "They can't" said his father. The boy was shocked.

Algernon grew up to be an engineer. Wherever he went he found steam being wasted and all the while he pictured this waste steam being used to drive fans, pump liquids, generate electricity and do a host of other useful jobs. Then he heard of the Hayward Tyler—Terry turbine and his delight knew no bounds, for it does just that. Used as a reducing valve, installed between boiler and processing plant, it can make steam do two jobs for the cost of one.



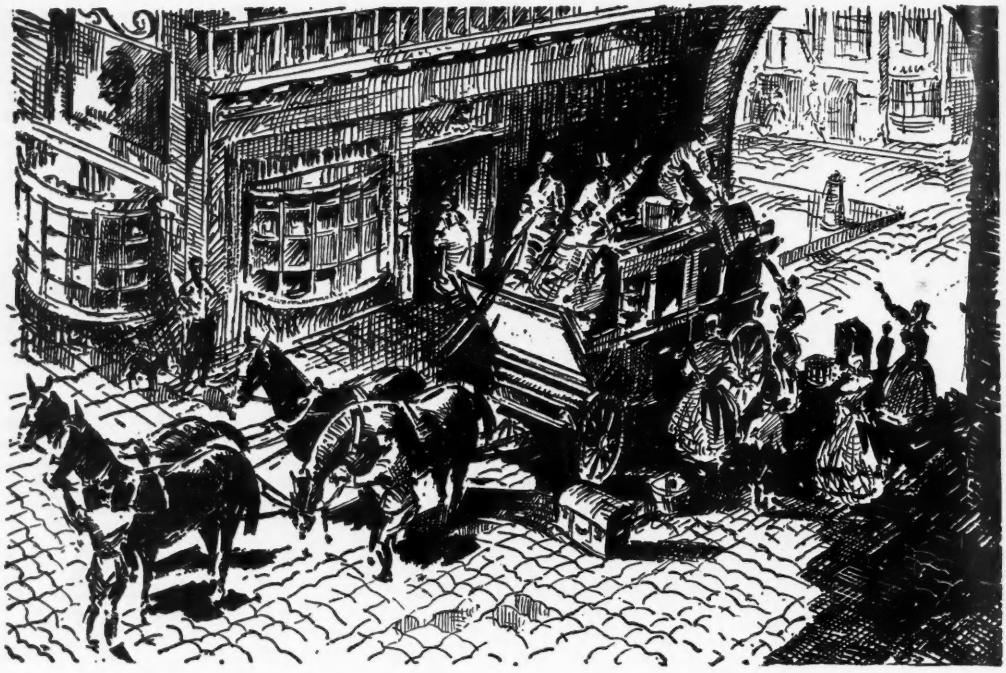
HAYWARD TYLER

& CO., LTD.

LUTON, BEDFORDSHIRE, ENGLAND

TELEPHONE LUTON 3951

LONDON OFFICE: 20 GROSVENOR PLACE, WESTMINSTER, S.W.I. TELEPHONE SLOANE 7552



At every stage . . .

In the field of compressed air engineering, quite another picture is presented by the phrase "at every stage", for here the problem is one of filtration . . . of preventing unnecessary breakdown and depreciation. Consider what happens in an unfiltered set-up. Atmospheric impurities enter by the compressor intake—water may collect or oil vapour be picked up in the compressor . . . scale and rust will form in the delivery pipes —and unless there is filtration at every stage, all these will enter the compressed-air-using tool causing rapid wear, early breakdown and loss of efficiency.

VOKES filters, with their 99.9 per cent. efficiency rating give complete protection against all these dangers and, by the simple renewal of filter elements when necessary, this protection is maintained year-in-year-out. Full details will gladly be supplied on request.

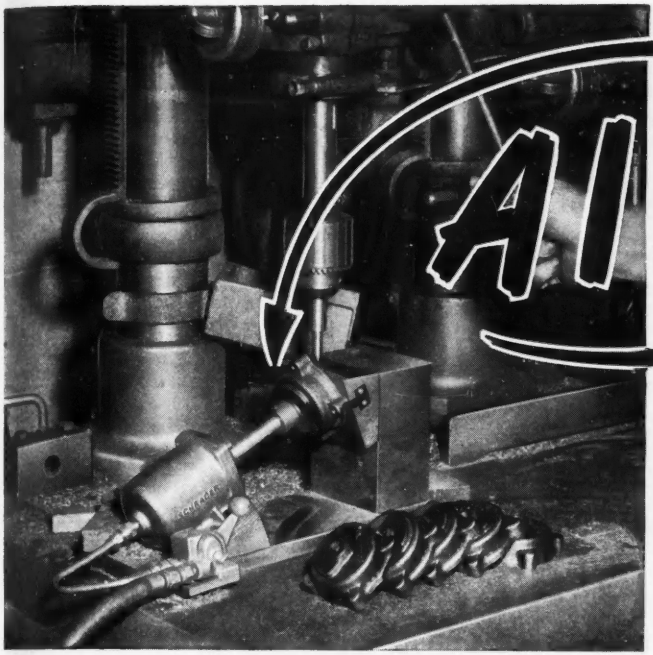
A typical VOKES compressed-air pipeline filter.

VOKES

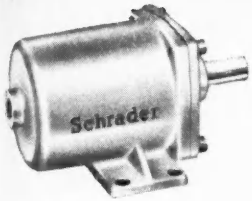
Pioneers of scientific filtration

VOKES LTD. Head Office: GUILDFORD, SURREY. London Office: 40 Broadway, Westminster, S.W.1

Vokes (Canada) Ltd., Toronto. *Represented throughout the world.* Vokes Australia Pty., Ltd., Sydney.



gives you quicker, safer, easier work holding



With the new Schrader clamps, air is used to hold work firmly in place for as long as is necessary — and with the same force every time. The action of the air cylinder is rapid and the push power is smooth and constant. Two types of mounting are available in a variety of cylinder sizes and piston stroke lengths. Many machining operations suggest natural locations for Schrader air clamps and there are numerous mechanisms into which they could be incorporated. This is yet another Schrader way of increasing machine output to the operators' advantage. Send the coupon for further details.

Schrader AIR CLAMPS

BANTAM
SLIDING SEAL CONTROL VALVES

THREE-WAY VALVES
Designed for use with the Schrader Air Clamp. The valve body houses a stainless steel disc which slides on a bronze ring, providing the positive sealing action.

WITH HAND LEVER
Designed for easy hand operation. Embodies the stainless steel disc as above, but available in two, three and four-way types.

WITH MECHANICAL LEVER
Constructional features identical with two, three and four-way types above, but incorporating a lever for mechanical actuation.

To: **A. SCHRADER'S SON**
(Division of Scovill Mfg. Co.), **829 TYBURN ROAD, ERDINGTON, BIRMINGHAM, 24**
Please send details of Schrader Air Clamps and Control Valves

Name .....
Address .....
E.D.23 .....

for ***REDUCED COST***
and ***IMPROVED PRODUCTION***
on ***MEDIUM and LONG RUNS***

ARCHDALE

Model "O"

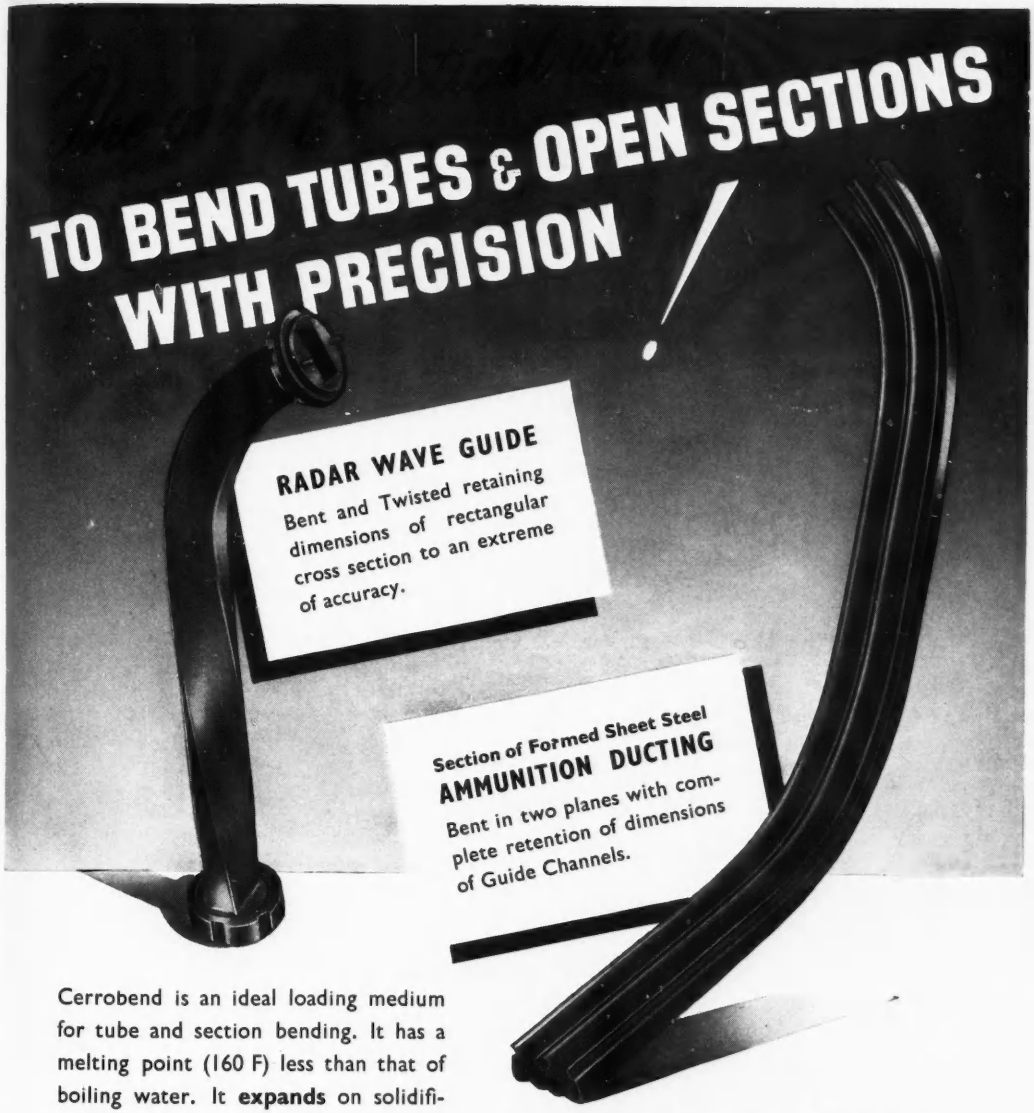
HYDRAULIC MULTIPLES

Supplied with up to 12 adjustable spindles for drilling up to ⅜ in. dia. in mild steel, this ARCHDALE model 'O' hydraulic multiple drill is fully engaged at Massey Harris Ltd., Manchester, on components for combine harvesters. In the component illustrated, 46 holes are drilled, varying from 17/64 in. to 21/64 in. dia.

These machines are supplied with circular or rectangular head frame, 10 in. dia., and 13 in. by 8½ in. respectively. Head is fixed and table is hydraulically fed.

JAMES ARCHDALE & CO., LTD
BIRMINGHAM 16 ENGLAND
SOLE AGENTS — ALFRED HERBERT LTD. COVENTRY

TO BEND TUBES & OPEN SECTIONS WITH PRECISION !


RADAR WAVE GUIDE
Bent and Twisted retaining dimensions of rectangular cross section to an extreme of accuracy.
Section of Formed Sheet Steel
AMMUNITION DUCTING
Bent in two planes with complete retention of dimensions of Guide Channels.

Cerrobend is an ideal loading medium for tube and section bending. It has a melting point (160 F) less than that of boiling water. It **expands** on solidification and thus enables the thinnest tubing to be bent to small radii as though it were a solid bar. Full technical data will be sent on request.

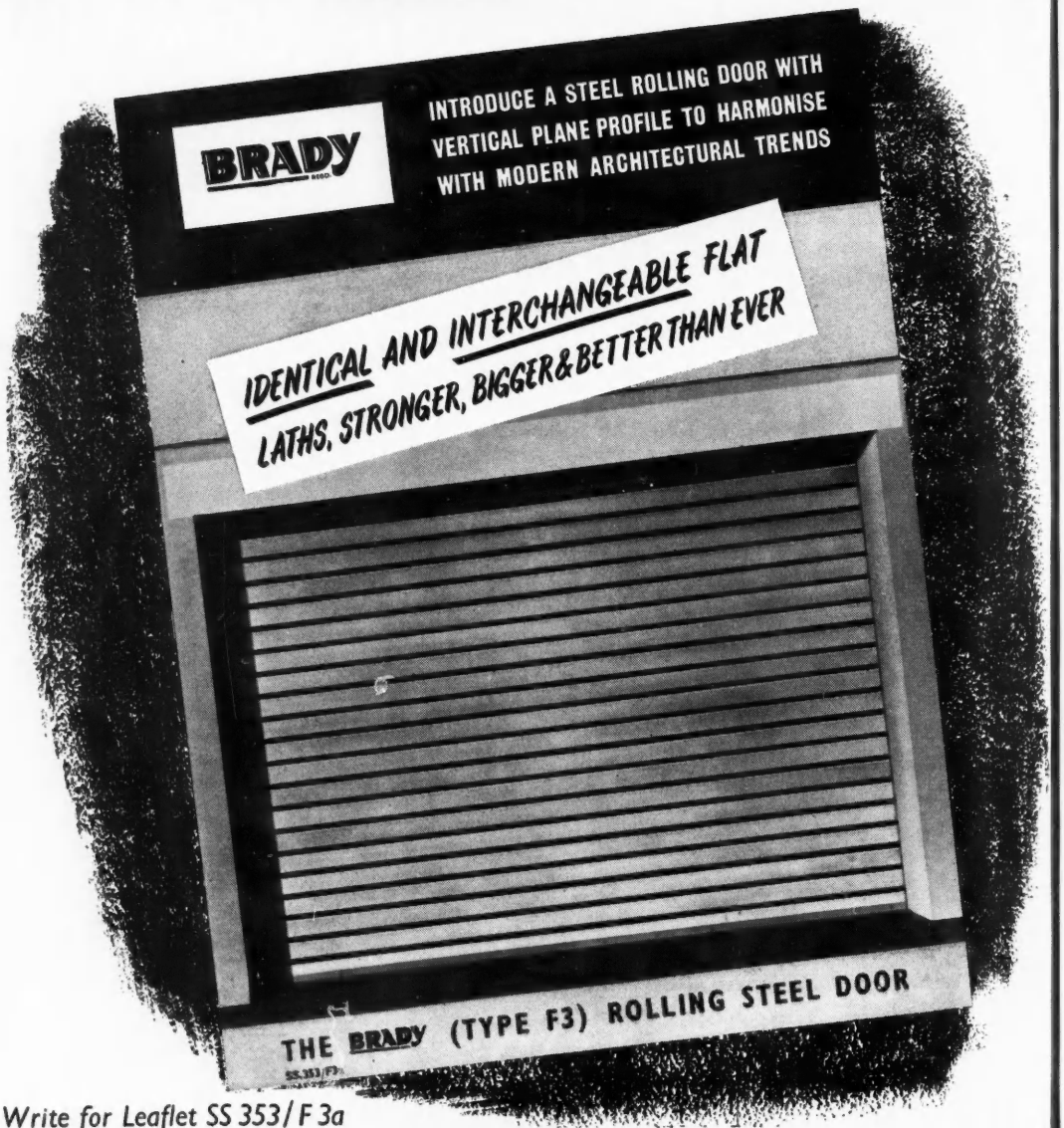
CERROBEND

Low-Temperature Melting Non-Shrinking Alloys

MINING AND CHEMICAL PRODUCTS LIMITED

86, STRAND (1st Floor), LONDON, W.C.2. **Telephone: TEMple Bar 6511 (3 lines)**

Another BRADY achievement


BRADY
INTRODUCE A STEEL ROLLING DOOR WITH VERTICAL PLANE PROFILE TO HARMONISE WITH MODERN ARCHITECTURAL TRENDS
IDENTICAL AND INTERCHANGEABLE FLAT LATHS, STRONGER, BIGGER & BETTER THAN EVER
THE BRADY (TYPE F3) ROLLING STEEL DOOR

Write for Leaflet SS 353/F 3a

G. BRADY & CO. LTD. MANCHESTER 4 *Telephone COLlyhurst 2797/8*

LONDON: New Islington Works, Park Royal, N.W.10 BIRMINGHAM: Rectory Park Road, Sheldon, 26
CANADA: David C. Orrock & Co. (G. Brady & Co. Canada Ltd.) 1405 Bishop Street, Montreal 25, Que.
and also at 23 Scott Street, Toronto, 1

U.S.A.: G. Brady & Co. Ltd., 11 West 42nd Street, New York 18, N.Y.
NORWAY: An Thorbjörnsen, Kongensgate, 14, Oslo And also at Cape Town

MANUFACTURERS OF BRADY HAND AND POWER OPERATED LIFTS

S. & B.

nylon... AND THE ENGINEER

Nylon has already established itself as an engineering material of great importance. Both in this country and in the U.S.A., nylon has *proved* itself, under the most stringent conditions, in many industrial applications.

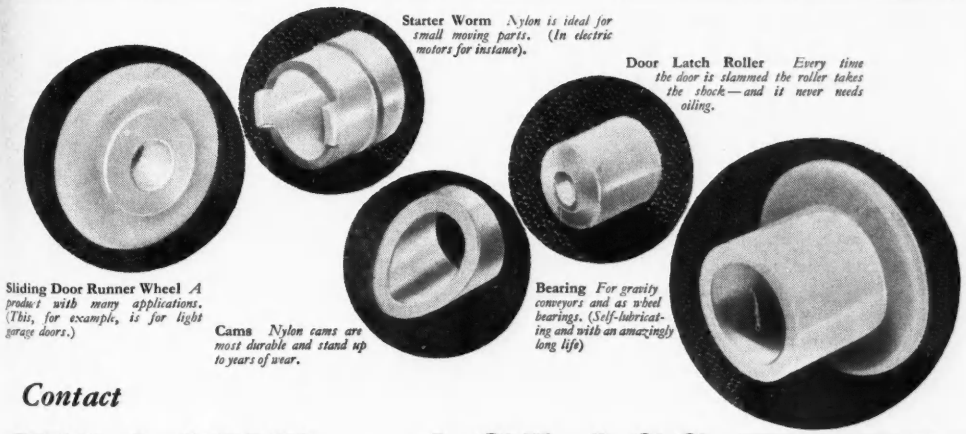
The advantages of the self-lubricating properties of moulded nylon when used as bearings or gears are obvious to the engineer; but this is only one of the many mechanical uses of this versatile material. A glance at the following list of its physical and mechanical properties will show you why NYLON has come to stay in the engineering world!

Extreme toughness
Excellent abrasion resistance
Stability at high temperatures
Very high weight/strength ratio
Good chemical resistance
Non-inflammability
Extremely low co-efficient of friction

Impact Strength
—1·1·5 ft. lb. per ¼" notch (B.S.S.771)
Tensile Strength
—10,000 - 11,500 lb. per sq. in.
Elongation —80 - 100%
Cross Breaking Strength
—12 - 15 x 10^3 lb. per sq. in.
Hardness 12 Vickers Diamond
Specific Gravity—1·14

All are average values measured on injection moulded test specimens.

We can supply a wide range of blanks for your own test purposes



Starter Worm *Nylon is ideal for small moving parts. (In electric motors for instance).*

Door Latch Roller *Every time the door is slammed the roller takes the shock—and it never needs oiling.*

Sliding Door Runner Wheel *A product with many applications. (This, for example, is for light garage doors.)*

Cams *Nylon cams are most durable and stand up to years of wear.*

Bearing *For gravity conveyors and as wheel bearings. (Self-lubricating and with an amazingly long life)*

Contact

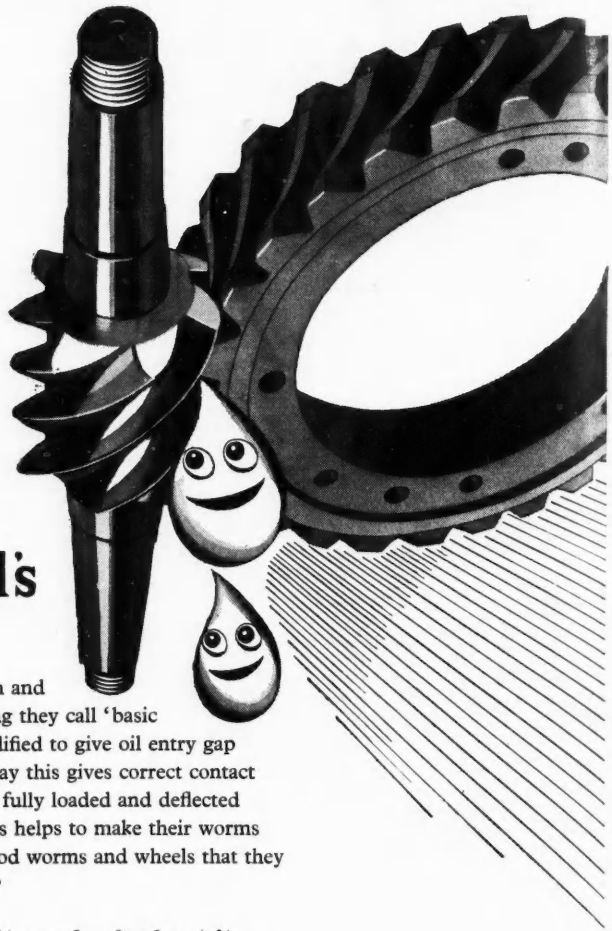
FRASER *and* GLASS

the plastics people — about NYLON

FRASER AND GLASS LTD., WOODSIDE LANE, LONDON, N.12. (HILLSIDE 2224-5)

NOW ON THE DRAWING BOARD—
Thread Guides for textile machinery

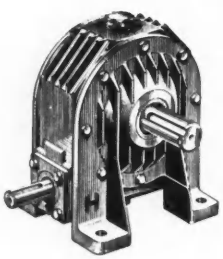
the things they do at Holroyd's



They make their wheel teeth and worm threads in something they call 'basic involute helicoid form, modified to give oil entry gap at contact lines'. They say this gives correct contact and oil film lubrication in fully loaded and deflected positions. They say this helps to make their worms and wheels the very good worms and wheels that they are. Any questions?

They've written a book about it—

about the way they make their worms and wheels, about gear selection and service, dimensions, efficiencies, lubrication and maintenance—all the facts a user needs on Holroyd Worm Gears and Worm Reduction Units. They'll be very glad to send *you* a copy. Their address is John Holroyd & Co. Ltd., Milnrow, Lancs.



QUICK DELIVERIES CAN BE MADE OF ALL

Holroyd WORM GEARS AND WORM REDUCTION UNITS

CRC 164

STANLEY HOWARD OFFERS

TIP & ROOT RELIEF

for both SPUR and HELICAL GEARS in a single operation by Involute Method with Rapid Reciprocations

KOLB

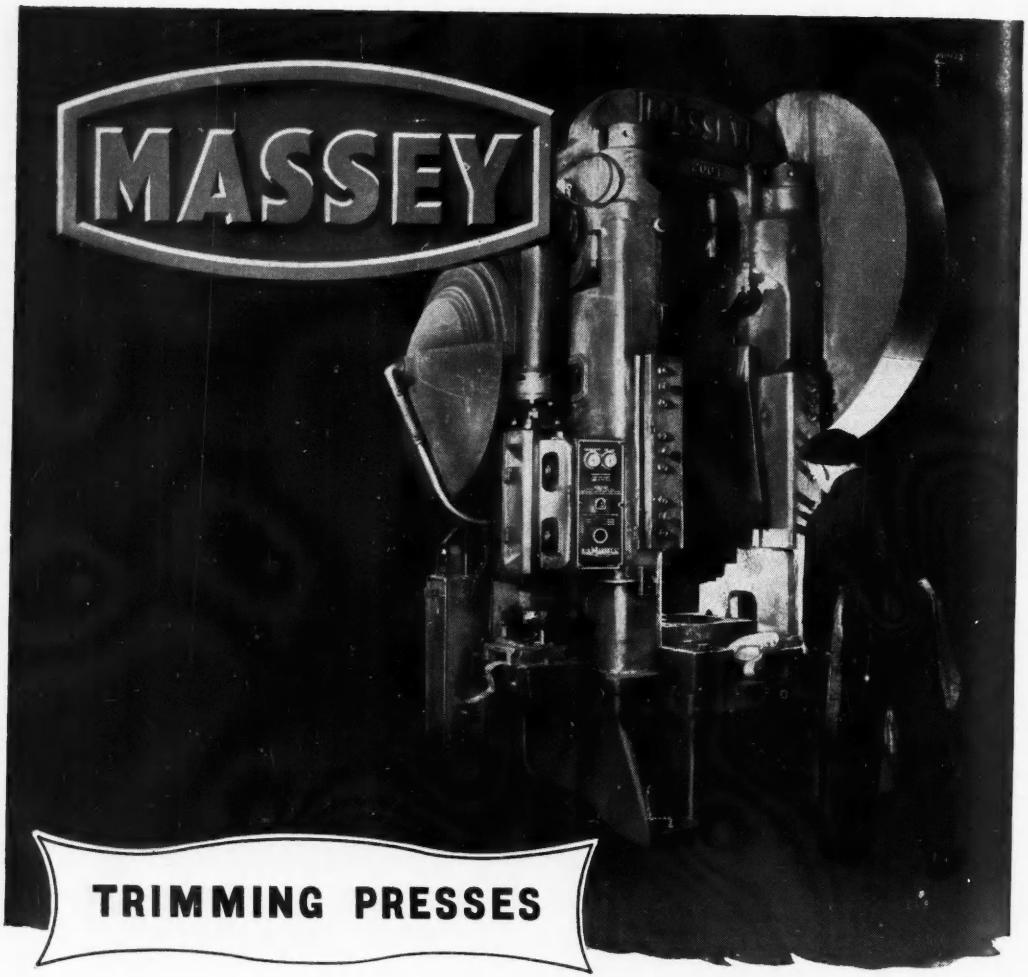
GEAR GRINDING MACHINES

Type K.Z.1 (above)
Type K.Z.2 (2 wheels)
For large batch production

We also supply KOLB column Drilling machines & Radial Drilling machines

★ *Please write for full particulars*

STANLEY HOWARD LTD
75-76, EXCHANGE BLDS.
STEPHENSON PLACE · BIRMINGHAM 2
Tel: MIDland 6815



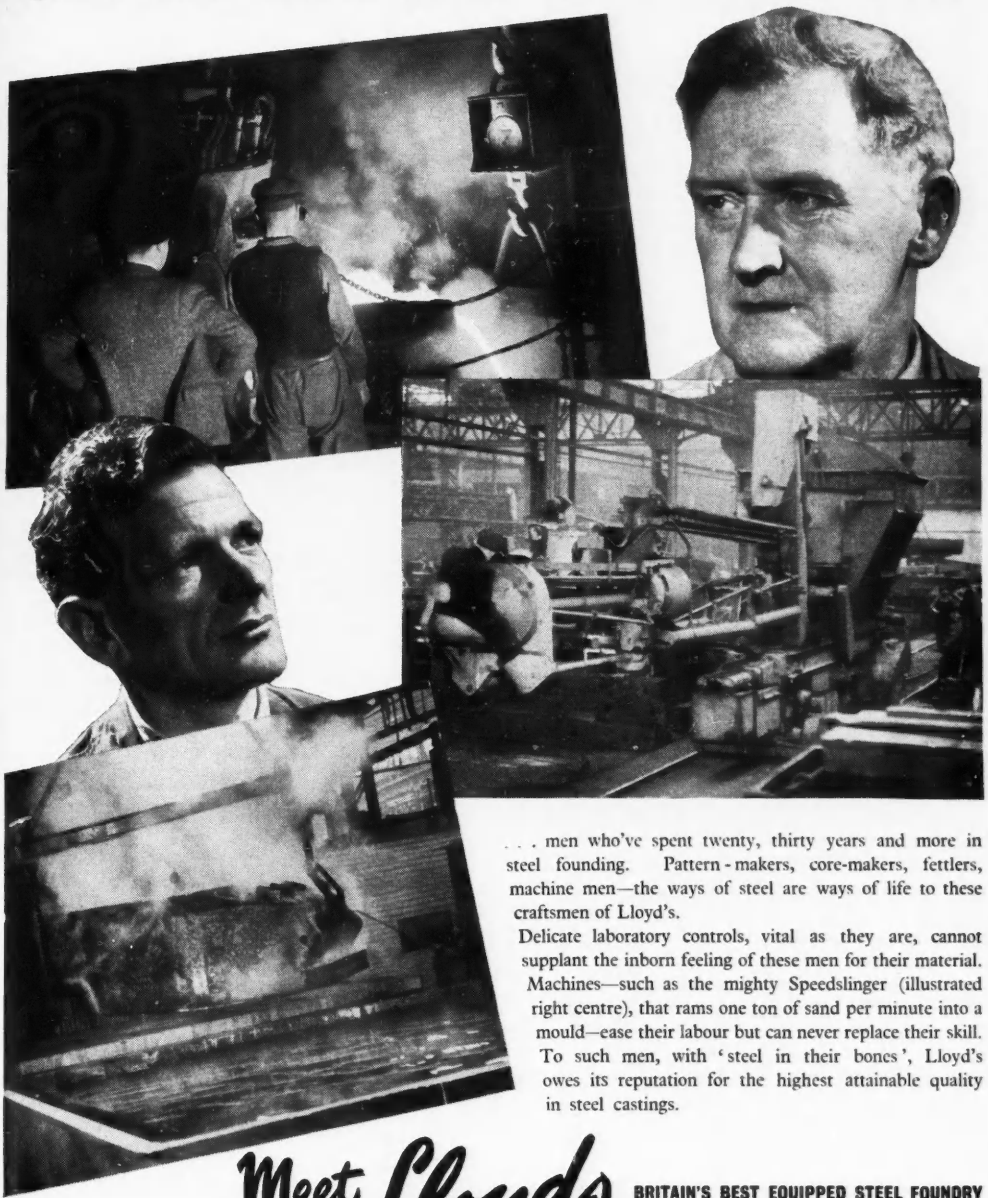
essential for high output

Flash removal is performed least expensively when suitable trimming presses are used, leaving the hammers to their proper duties. The Massey range of trimming presses comprises two groups to meet all needs . . . geared types in sizes up to 750 tons for medium and large forgings: and direct-acting types up to 200 tons for smaller work. The auxiliary ram at the side of the machine is a very useful adjunct.

Makers of the World's greatest range of forging plant including Pneumatic Power Hammers, Steam and Compressed Air Hammers, Spring Power Hammers, Double-acting Steam and Compressed Air Drop Hammers, Forging Presses, Tyre Fixing Rolls. Send for fully illustrated catalogues.

B. & S. MASSEY LTD OPENSHAW · MANCHESTER · ENGLAND

Meet the men who know steel best



. . . men who've spent twenty, thirty years and more in steel founding. Pattern-makers, core-makers, fettlers, machine men—the ways of steel are ways of life to these craftsmen of Lloyd's.

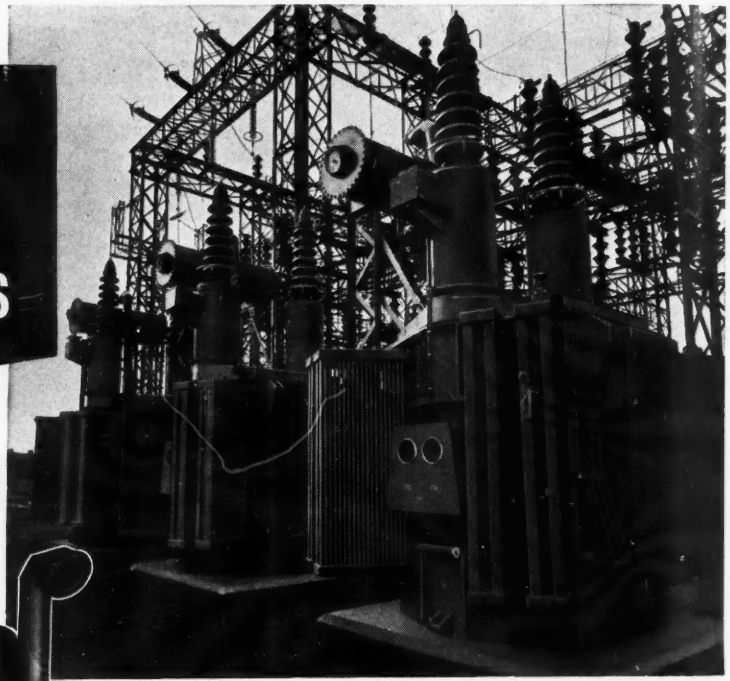
Delicate laboratory controls, vital as they are, cannot supplant the inborn feeling of these men for their material. Machines—such as the mighty Speedslinger (illustrated right centre), that rams one ton of sand per minute into a mould—ease their labour but can never replace their skill. To such men, with 'steel in their bones', Lloyd's owes its reputation for the highest attainable quality in steel castings.

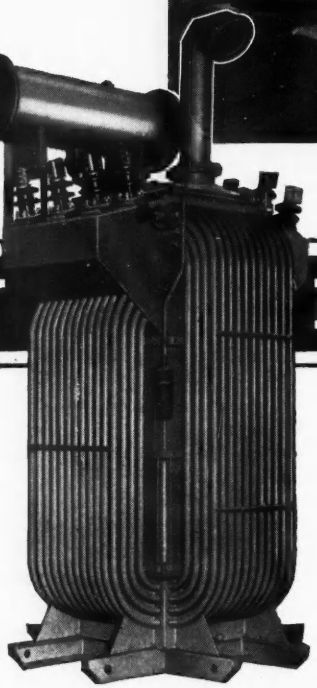
Meet Lloyds BRITAIN'S BEST EQUIPPED STEEL FOUNDRY

F. H. LLOYD & CO. LTD., JAMES BRIDGE STEEL WORKS, WEDNESBURY, STAFFS . TELEPHONE: DARLASTON 225

A Print for Industry Ltd., Advertisement

CURRENT LIMITING REACTORS





BY HACKBRIDGE

Whether magnetically or copper shielded, Hackbridge reactors embody the Hackbridge principle of unit construction: in either type the whole assembly constitutes a rigid structure of exceptional mechanical strength to withstand the largest electro-mechanical stresses met with under service conditions. Send for publication DB.18/1.

The illustrations show typical Hackbridge magnetically shielded reactors. Above: at Coventry Generating Station for introducing 18% reactance into the 90 MVA 132 kV. system; and below, for introducing a 3.75% reactance into a 30 MVA 6.6 kV. system.

HACKBRIDGE AND HEWITTIC ELECTRIC CO., LIMITED
WALTON-ON-THAMES - SURREY - ENGLAND
Telephone : Walton-on-Thames 760 (8 lines) *Telegrams : "Electric, Walton-on-Thames"*

POWER!

for Industrial Purposes

Ford

ENGINE 12 HOURLY RATINGS

- **933 cc. PETROL (4 cyl.)**
  8 B.H.P. @ 1500 R.P.M.
  13·75 B.H.P. @ 2500 R.P.M.
- **1172 cc. PETROL (4 cyl.)**
  11·5 B.H.P. @ 1500 R.P.M.
  19 B.H.P. @ 2500 R.P.M.
- **1508 cc. PETROL (4 cyl.)**
  17 B.H.P. @ 1500 R.P.M.
  28 B.H.P. @ 2500 R.P.M.
- **2262 cc. PETROL (6 cyl.)**
  24 B.H.P. @ 1500 R.P.M.
  40 B.H.P. @ 2500 R.P.M.
- **3621·5 cc. PETROL (V-8 cyl.)**
  34 B.H.P. @ 1500 R.P.M.
  56 B.H.P. @ 2500 R.P.M.
- **3260 cc. PETROL (4 cyl.)**
  22 B.H.P. @ 1000 R.P.M.
  35·5 B.H.P. @ 1600 R.P.M.
- **3610 cc. VAPORISING OIL (4 cyl.)**
  22 B.H.P. @ 1000 R.P.M.
  34·5 B.H.P. @ 1600 R.P.M.
- **3610 cc. DIESEL (4 cyl.)**
  22 B.H.P. @ 1000 R.P.M.
  36 B.H.P. @ 1600 R.P.M.

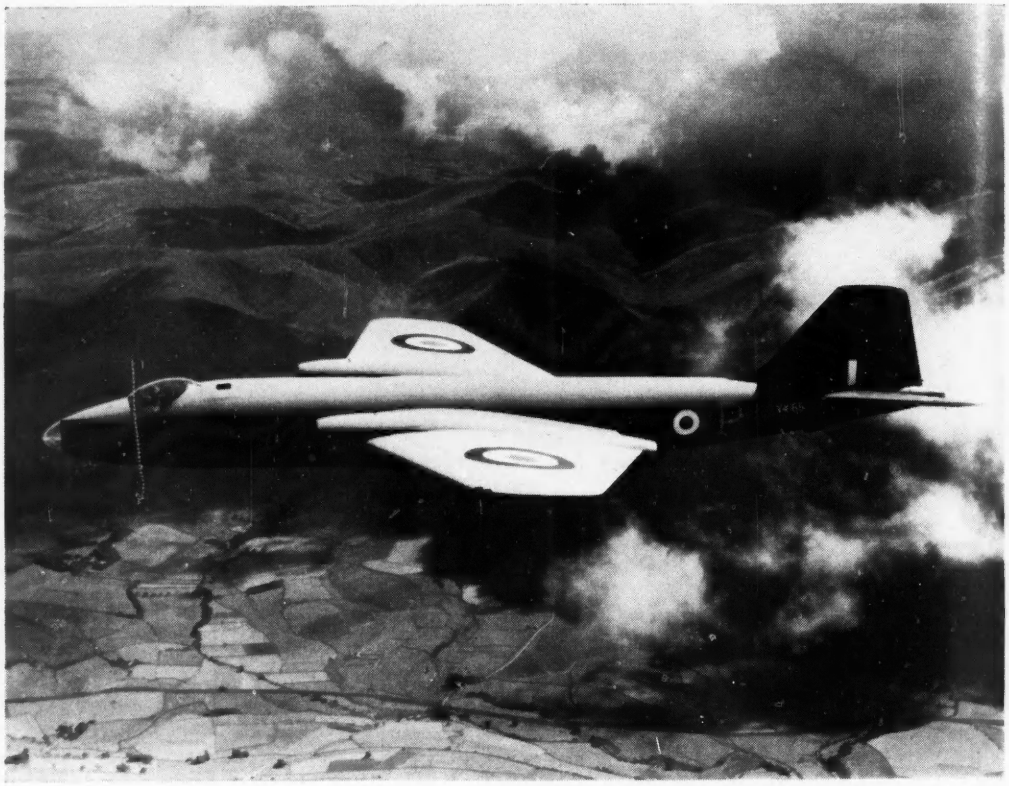
Now a great new star joins the range of Ford Industrial Units—an entirely new 4-cylinder diesel engine capable of maintaining 34 B.H.P. continuously at 1500 R.P.M.

Full details of this and all other engines in the range are obtainable from our Industrial Units Dept.

DIEU ET MON DROIT

BY APPOINTMENT MOTOR VEHICLE MANUFACTURERS TO THE LATE KING GEORGE VI

FORD MOTOR COMPANY LTD · DAGENHAM · ESSEX

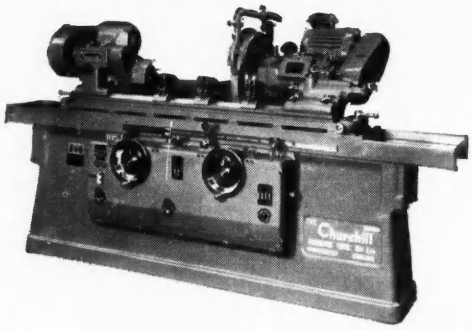


'English Electric' **Canberra** (*Photograph by permission*)

Churchill

By their ability to maintain low limits and fast production rates CHURCHILL Precision Grinders make an important contribution to the outstanding achievements of the British Aircraft Industry.

Illustrated here is the CHURCHILL Model 'BW' 10″ × 36″ Plain Grinding Machine; can be supplied as a non-automatic or a fully automatic Plain Grinding Machine.



THE CHURCHILL MACHINE TOOL CO. LTD., BROADHEATH, NR. MANCHESTER.

Export Sales Organisation : Associated British Machine Tool Makers Ltd., London, Branches and Agents.

Home Selling Agents : Charles Churchill & Co. Ltd., Birmingham and Branches.

PRECISION *plus* PRODUCTION

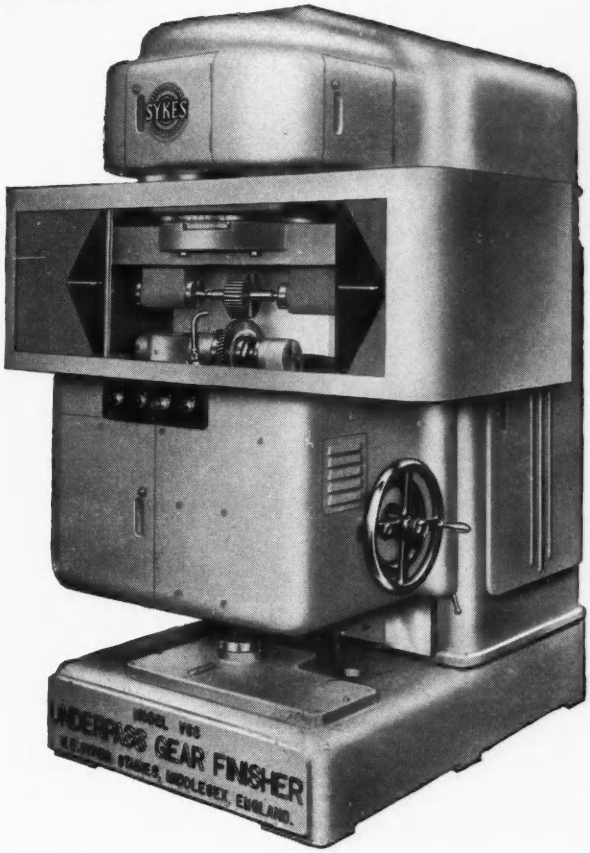
C642A

Better finish

Greater accuracy

Increased output

Lower production costs



SYKES

VS.8 UNIVERSAL

UNDERPASS

ROTARY GEAR FINISHING MACHINES

CAPACITIES 1″ to 8″
1″ to 12″
1″ to 18″

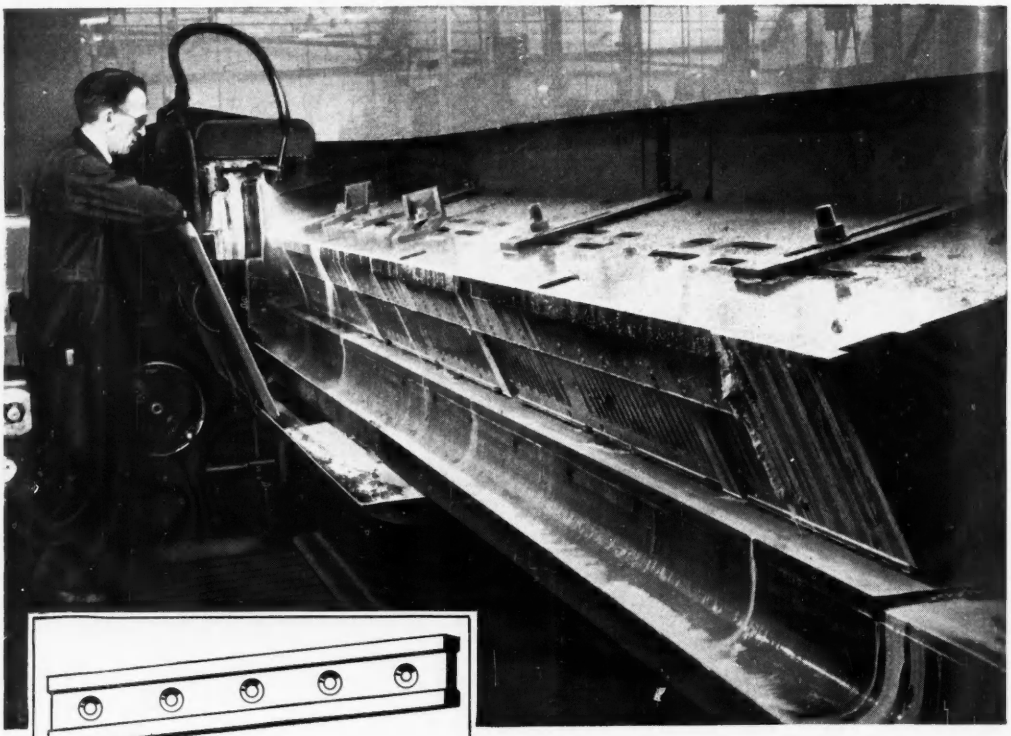
MAX. FACE WIDTH 5″

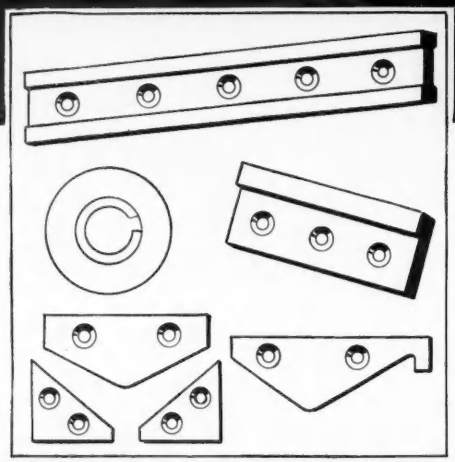
Full technical data on request

W. E. SYKES LIMITED

STAINES • MIDDLESEX • ENGLAND

Telephone: Staines 4281 *Telegrams: "Sykutter, Staines"*





We have the specialist knowledge and plant necessary for the manufacture of shear blades up to the largest sizes and invite enquiries for shear blades for plate and sheet; angle cutters; bar cropping blades and blades for hot shearing.

We are also large makers of circular cutters for slitting cold rolled strip, supplied in high speed steel or electrically melted Sanderson tool steels.

SANDERSON

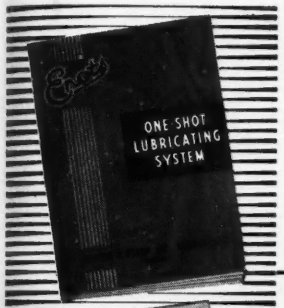
The photograph shows a horizontal head surface grinder with capacity for blades and knives up to 14 feet long.

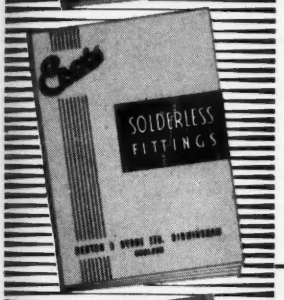
Shear Blades

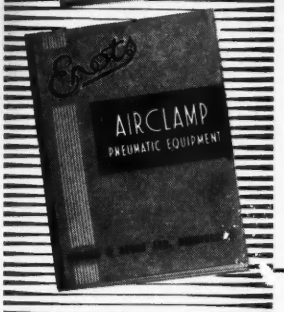
Sanderson Brothers and Newbould Limited, Attercliffe Steelworks, Sheffield. *Est. 1776*

A SABEN PRODUCT

Tool Steels, Machine Knives, Metal Cutting Saws, Hacksaw Blades, Files.

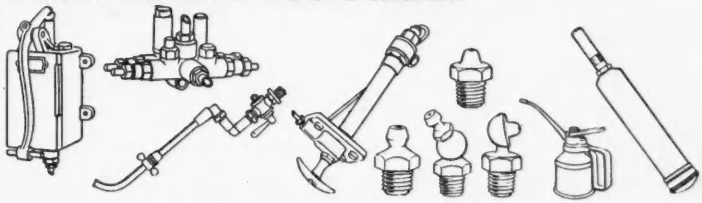






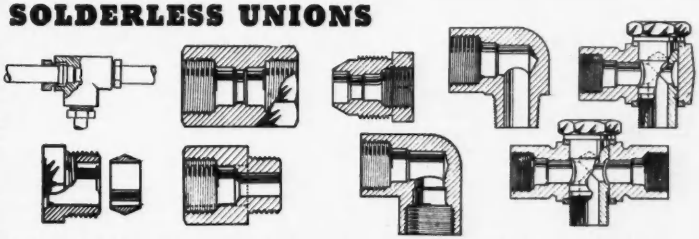
Enots

LUBRICATING EQUIPMENT



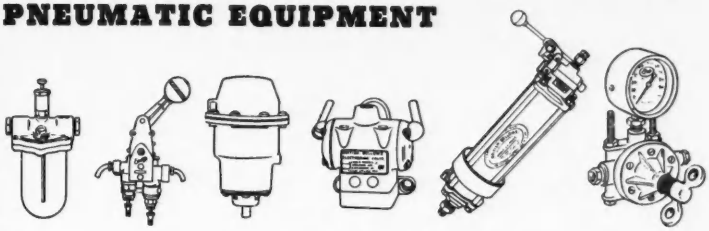
"ONE SHOT" & "BENSTON" LUBRICATION SYSTEMS · COOLANT FITTINGS · NIPPLES · OIL CANS ETC.

SOLDERLESS UNIONS



NUTS · SLEEVES · CONNECTORS · ADAPTORS · TEES · ELBOWS · BANJOS · COPPER TUBE · ETC.

PNEUMATIC EQUIPMENT



AIR CYLINDERS · HAND, FOOT & SOLENOID CONTROL VALVES · "BELLOWS" AIR HYDRAULIC FEED · ETC.

"**Enots**" lubricating systems are used in all branches of industry and this service coupled with a range of air cylinders, control valves and other pneumatic equipment (including the "British Bellows" Air Hydraulic Feed Unit manufactured by Geo. H. Hughes Ltd.) has been the means of contributing in considerable measure to the increased output of many manufactures at home and abroad.

Our technical representatives are ready to advise on any problem regarding the use of our equipment, and appropriate literature is available on request.

aids to greater efficiency

BENTON & STONE LTD., ASTON BROOK ST., BIRMINGHAM, 6, ENGLAND

Telephone: Aston Cross 1905.

A JOHN SMITH Special

Occasionally we are confronted with a lifting problem which taxes even our designers' brains. The crane illustrated above is a case in point. An overhead crane was required to handle fabricated boiler sections, but on examining the building we found that this was not strong enough to take the weight of a standard type. Eventually it was decided to remove an existing vertical roof support, and re-erect it inside a hollow steel column. The crane revolves around this central column and has a lifting capacity of 3 tons at a maximum radius of 23'-6". The hoisting is electrically driven and the load is traversed by hand power. Such cases as this are comparatively rare, and the majority of indoor lifting problems can be solved by one of our standard overhead cranes, which range in capacity from 2 to 25 tons, or by similar cranes of larger capacities up to 75 tons which can be made according to requirements.

Perhaps you have a handling problem which could be solved by the right overhead crane? If so, you are invited to write for our technical advice, which will be given freely and without obligation.

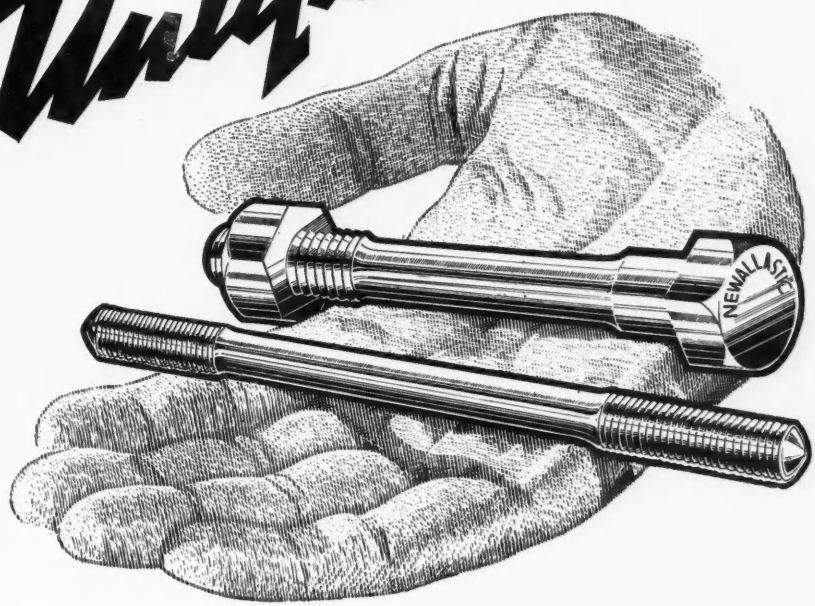
JOHN SMITH (Keighley) LTD

THE CRANE WORKS · KEIGHLEY · YORKS · TEL. 2283/4 & 2035

London Office: Buckingham House, 19/21 Palace St. (off Victoria St.) S.W.1. Tel: Tate Gallery 0377/8.
Southern Counties Office: Brettenham House, Lancaster Place, Strand, London, W.C.2. Tel: Temple Bar 1515.

495

Unique

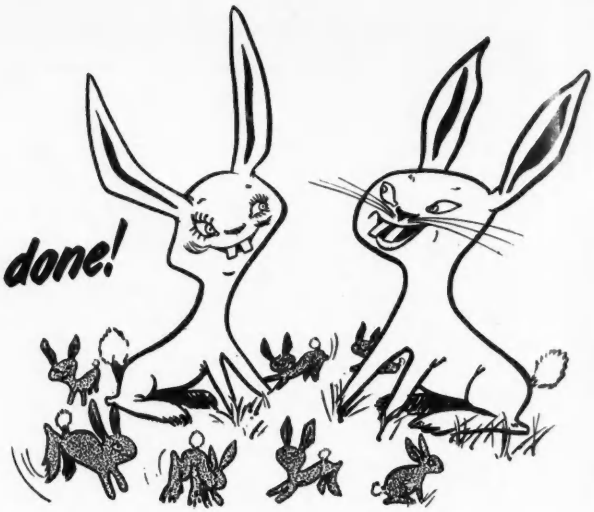


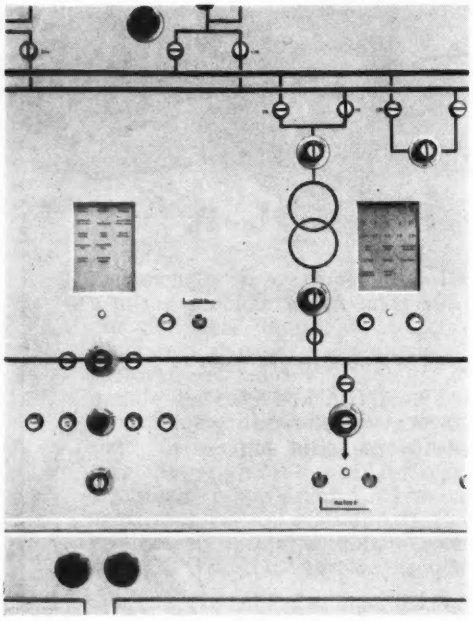
"Newallastic" bolts and studs have qualities which are absolutely unique. They have been tested by every known device, and have been proved to be stronger and more resistant to fatigue than bolts or studs made by the usual method.

C. P. Newall & Co., Ltd.

POSSILPARK GLASGOW · N

no sooner said than done!





. . . was once regarded as the acme of speed. Today, the control engineer can substitute "thought" for "said". No need for the modern controller continually to be telephoning distant engineers . . . he just reaches out a finger and carries out all necessary operations via *Standard* Centralised Supervisory Control. Nowadays the control engineer can be in continuous touch with his network, no matter how extensive or geographically inaccessible. Pilot lines carry coded impulse trains to select and actuate, or interrogate, the switchgear in unattended subs so that supervison can be exercised more quickly than telephone contact could be made.

Centralised Supervisory Systems using coded impulse trains have been specially designed for use where pilot lines are scarce. Systems developed and pioneered by *Standard* are fully safeguarded by the Constant Total feature which prevents maloperation if signals happen to be mutilated by, say, induced voltages or any other cause.

Close-up of a section of a miniature control diagram panel for the complete control and indication of 132-kV feeder breakers, bus coupler, and transformers, indication only of isolators, alarms and metering and facilities for syncronising.

Standard

Supervisory Remote Control Systems

Standard Telephones and Cables Limited

Registered Office: Connaught House, Aldwych, London, W.C.2.

TELEPHONE DIVISION: OAKLEIGH ROAD, NEW SOUTHGATE, N.11

Serving Modern Industry

'VSG'

Regd Trade Mark

Infinitely VARIABLE SPEED HYDRAULIC TRANSMISSION GEARS

JOHNSON & PHILLIPS LTD
ALUMINIUM SHEATHING PLANT

Aluminium Sheathed Cable, pioneered and developed by Johnson & Phillips Ltd., for its cheapness, lightness and ease of installation, requires a special manufacturing technique. Owing to the difficulty of extrusion, oversize aluminium tube is drawn down on to the cable through a die by a large diameter Hauling Gear. For this process, as for many others in modern industry, accurate speed control and high torque at low speeds are essential. 'VSG' Drives have been selected to meet these requirements.

Are you aware of the full possibilities of 'VSG' Hydraulic Power Transmission? May we send you further particulars?

VICKERS-ARMSTRONGS LTD

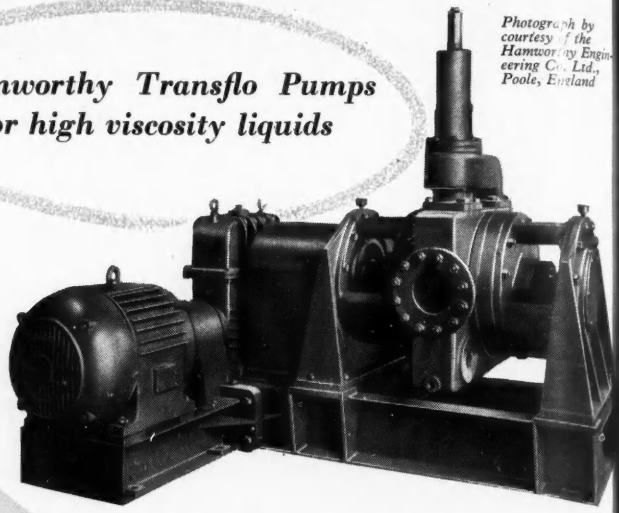
VICKERS HOUSE · BROADWAY · LONDON · S.W.1 *Telephone:* ABBEY 7777

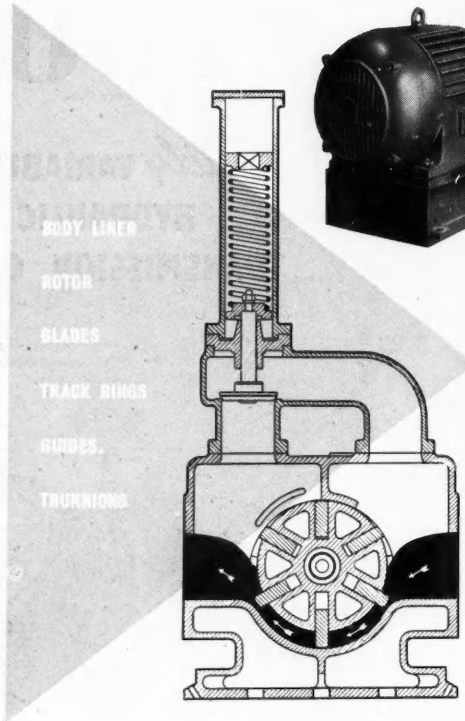
DIS

G

Hamworthy Transflo Pumps for high viscosity liquids

Photograph by courtesy of the Hamworthy Engineering Co. Ltd., Poole, England





MEEHANITE METAL CASTINGS

for resistance to wear and corrosion

Pumping molasses at 120 gallons per minute is typical of the heavy tasks Hamworthy pumps perform. Sound castings are needed. For these, as for pumps of all types, *Meehanite* castings have proved outstandingly dependable in providing resistance to pressure, corrosion and wear. When other properties are required in a casting — heat resistance or any of the combination of qualities demanded in general engineering — there is a type of *Meehanite* metal that is right for the particular casting.

For uniformly good castings, consult a Meehanite Foundry.

MEEHANITE METAL FOUNDRIES AT YOUR SERVICE

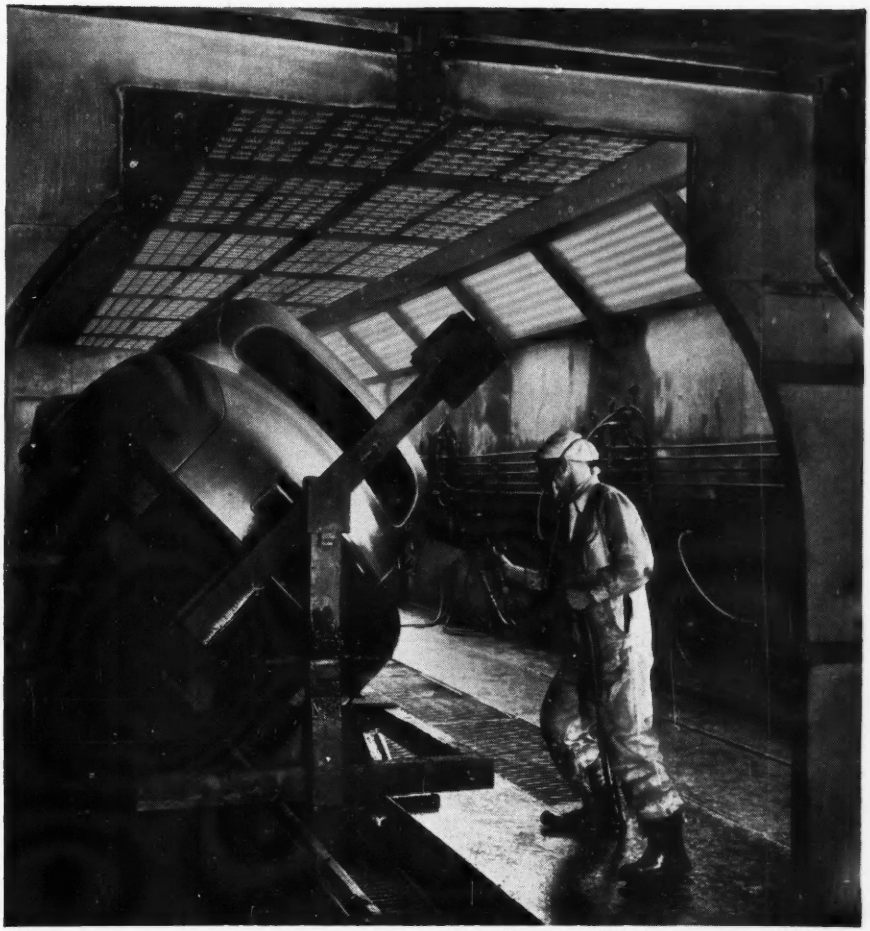
HOW MEEHANITE METAL CAN HELP YOU

Write for a copy of "The Specification of Meehanite Metal;" MS107M to any of the Meehanite Foundries listed

The Butterley Company Limited. Ripley, Derby.
Cameron and Roberton Limited. Kirkintilloch.
Carmichael Bros. Limited. Nile Street, South Shields.
Goulds Foundries Limited. Cardiff and Newport, Mon.
John Harper (Meehanite) Limited. Willenhall, Staffs.
G. M. Hay and Company Limited. Glasgow.
C. A. Parsons and Company Ltd. Newcastle-on-Tyne, 6
Qualcast (Ealing Park) Ltd. London, W.5.
Richards (Leicester) Limited. Leicester.
Southern Foundries Ltd. Waddon, Croydon, Surrey.
Winget Limited. Rochester.
Ashmore, Benson Pease and Co. Stockton-on-Tees.

Meehanite
THE DEPENDABLE Metal

THE INTERNATIONAL MEEHANITE METAL COMPANY LIMITED
66 VICTORIA STREET, LONDON, S.W.1. *Telephone: VICtoria 9921-22 Telegrams: Meerion Phone London*



Rover Car Factory, Solihull. High intensity lighting in a body spray tunnel by fluorescent lamps in a glazed enclosure.

Tailored for the job

The lighting of many processes is vital to the smooth and rapid flow of work and to the quality of the finished product. For example, poor lighting could make a spray tunnel into a bottle-neck — each job taking a little too long, a little portion missed, a return to the spray line — and so the whole production line marks time. Whatever form it takes, good lighting not only helps to provide a satisfactory working environment but is an active production tool.

Fluorescent lighting is as good as daylight — only more consistent. It is efficient; it is economical; and it is *flexible*. You can 'tailor' it, easily and exactly, to the special requirements of production at all stages.

HOW TO GET MORE INFORMATION

Your Electricity Board will be glad to advise you on how to use electricity to greater advantage — to save time, money, and materials. The new Electricity and Productivity series of books includes one on lighting — "Lighting in Industry". Copies can be obtained, price 9/- post free, from E.D.A., 2 Savoy Hill, London, W.C.2, or from your Area Electricity Board.

Electricity for PRODUCTIVITY

Issued by the British Electrical Development Association

M52R

now make the most of COPPER

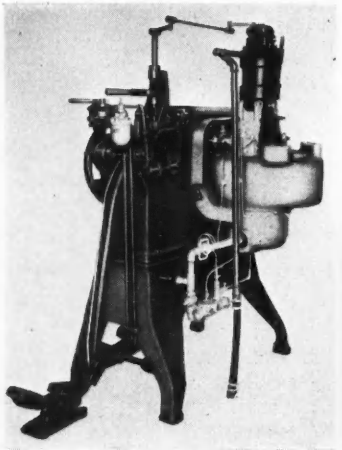
with the help of the C D A...

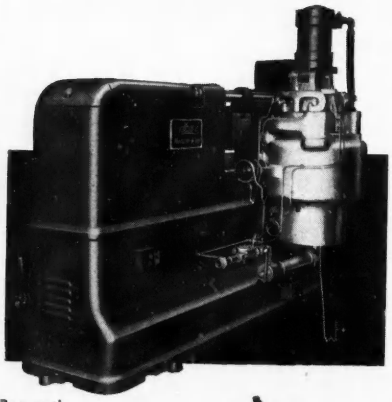
Copper is once again freely available for unrestricted use. The choice of the right grade or alloy—and its use in the right way—saves time, money and material. The C.D.A. exists to help you with expert advice on any of the varied uses of copper and with technical publications, obtainable on application—all free of charge.

COPPER DEVELOPMENT ASSOCIATION · KENDALS HALL · RADLETT · HERTS · TEL: RADLETT 5616

THE COULTHARD MADISON-KIPP

RANGE OF PRESSURE DIE CASTING MACHINES FOR ZINC LEAD TIN ALLOYS

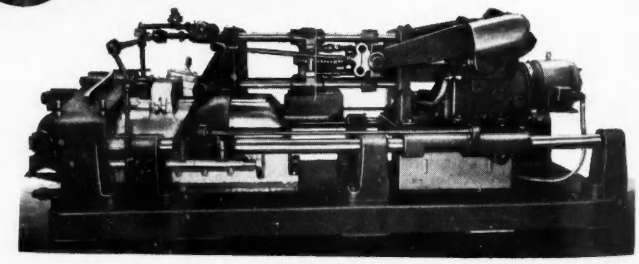




THE GIANT KIPPCASTER MODEL 500. For Larger Zinc, Lead and Tin Alloy parts. Capacity up to 3¼ lbs. in Zinc.

The Fully Automatic Model No. 4 Machine. For still larger parts. Capacity up to 25 lbs. in Zinc.

The Standard Kippcaster Model 215. The Fully Pneumatic Kippcaster is the most popular diecasting machine built today. It produces high quality Zinc, Lead or Tin Alloy parts at a higher rate of speed and lower cost. Capacity up to 1½ lbs in Zinc.



Manufactured in England by:

WM. COULTHARD & CO. LTD.

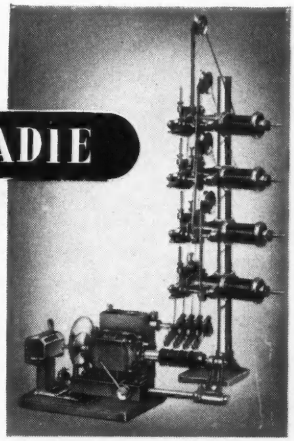
DURRANHILL ROAD
CARLISLE · ENGLAND

Phone: Carlisle 21418 *Grams: Kip Carlisle*

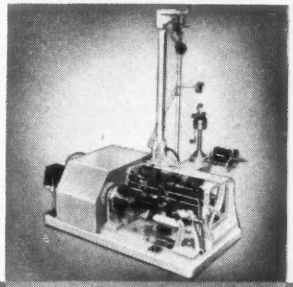
DOUGLAS and MACADIE
Coil winding
MACHINES

The machines here illustrated are typical examples of the extensive range of precision-built "Douglas" and "Macadie" Coil Winders, noteworthy for their superiority of design and unexcelled standard of efficiency. They have been described by an overseas buyer as "the most rugged, most versatile Coil Winders in the world".

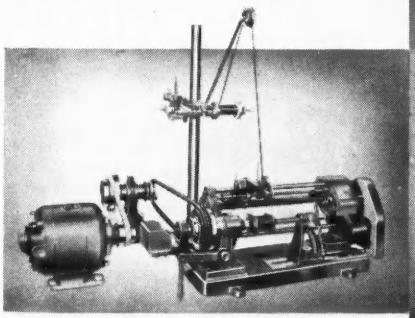
Models are available for the production of windings for every industrial requirement at highest speeds and with maximum economy. Enquiries for special purpose machines are invited, and any of our standard machines can be modified to cope with particular requirements.



"DOUGLAS" SMALL MULTI-WINDER



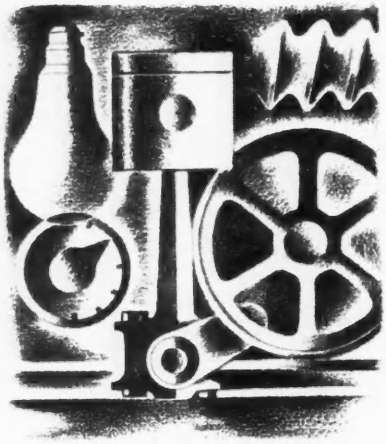
"DOUGLAS" No. 15 COIL WINDER



"DOUGLAS" No. 6 COIL WINDER

The AUTOMATIC COIL WINDER & ELECTRICAL EQUIPMENT CO. LTD.

WINDER HOUSE · DOUGLAS STREET · LONDON · S.W.1 · TEL · VICtoria 3404-9



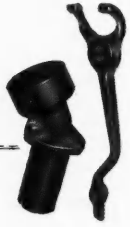
Did not obstruction's vessel hem it in,
Force were not force; would spill itself in vain..
(*Francis Thompson*)

Resistance is the necessary complement of force.

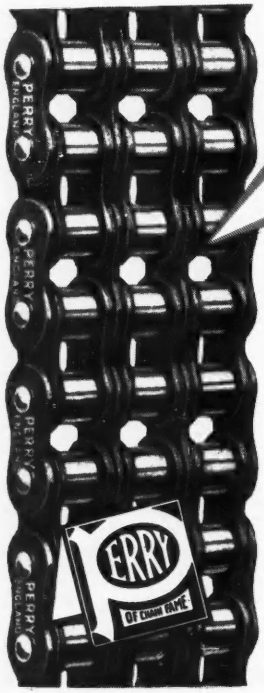
On that principle is based the effectiveness of steam, hydraulic and electrical power, as also the shaping and compacting of metal to toughened fibre, as in the production of Drop Forging.

This same law also rules in human affairs. The character of an individual or firm can be shaped and strengthened by recognising obstructions and difficulties as essential components of achievement.

S·W·F
PRESS & DROP FORGINGS



SOUTH WALES FORGEMASTERS LTD
GARTH WORKS • TAFFS WELL • CARDIFF
"Grams: "FORGEMASTERS," TAFFS WELL "Phone: TAFFS WELL 41/2

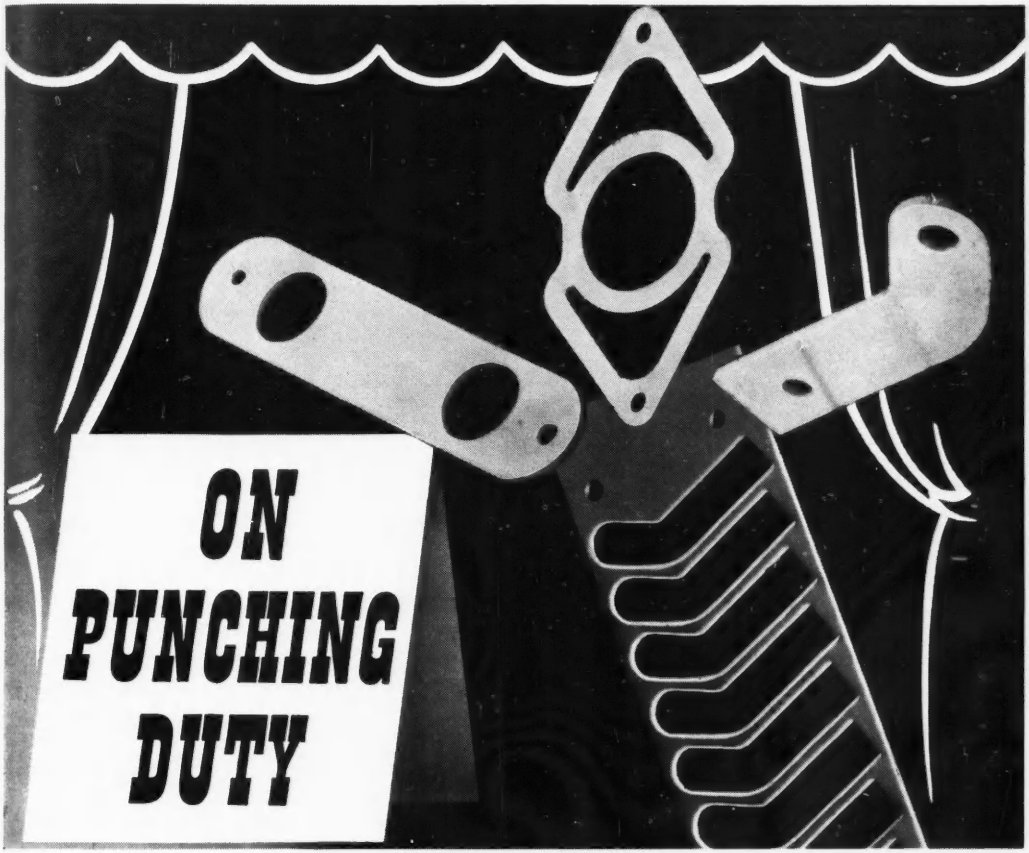


DEPENDABLE
is the word for
PERRY
CHAIN DRIVES

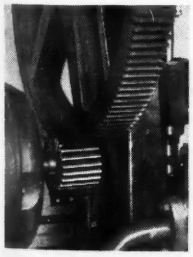
Industry forges ahead when Perry chain drives are on the job. Whatever *your* driving problem may be, profit from the expert know-how of Perry technicians. They've been solving similar problems for years and years.

For illustrated brochure and full details of Perry industrial chain drives and accessories, please write to

PERRY CHAIN CO. LTD., TYSELEY, BIRMINGHAM



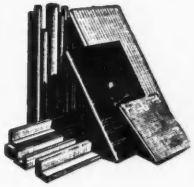
Fair grounds exist for asserting in no roundabout manner that punchings in Tufnol are unbeatable in quality. But the uses of Tufnol only begin here, and its real possibilities are unlimited. When hardwood or metal show deficiencies in service, then Tufnol will most likely fill the bill. Structurally strong, light in weight, with chemical resisting and electrical insulating qualities, unaffected by moisture or climatic exposure—it exhibits a remarkable combination of properties. Added to this is its advantage of being easily and accurately machinable with ordinary workshop facilities. The prefabricated forms—sheets, tubes, rods, bars, angles and channels—reduce production costs: and specially moulded shapes or finished parts can be supplied to any specification. Tufnol has put many an extra punch into Britain's export drive!



A Tufnol Pinion meshing with a cast-iron wheel. The 18 h.p. motor provides the pump drive for a Hydraulic Accumulator.

CONTINUOUS PERFORMANCE

Every day Tufnol is solving fresh problems. Technical publications have already been compiled dealing with the different aspects of Tufnol, but if your enquiry poses a NEW problem, our Technical Staff will work on it with enthusiasm. Why not write TODAY?



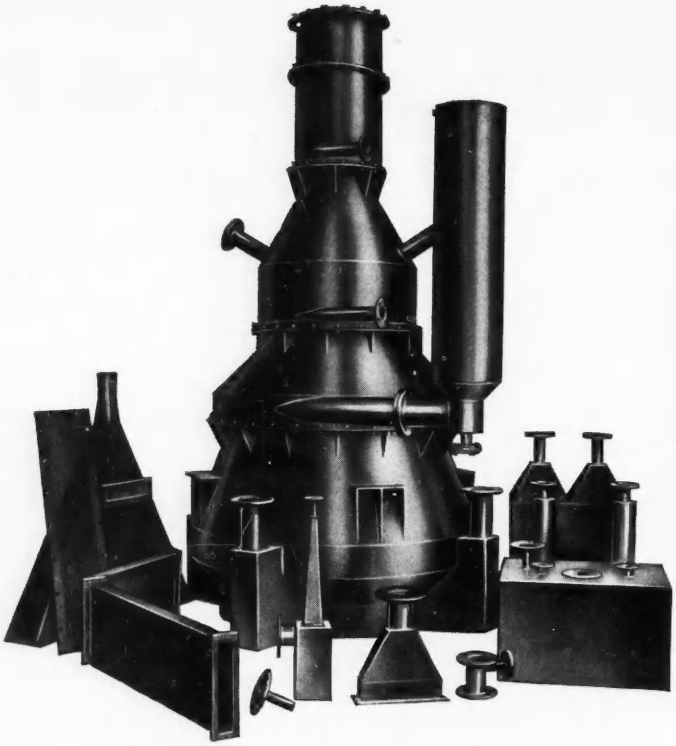
TUFNOL

REGISTERED TRADE MARK

An ELLISON Product

TUFNOL LTD • PERRY BARR • BIRMINGHAM • 22B

254



This vessel, approximately 18′ - 0″ in height is constructed from $\frac{3}{16}$″ to $\frac{3}{8}$″ Plate and is typical of the class of work done by us.

For fabrications in Steel, Stainless Steel and Non-ferrous metals, send your enquiries to:-

W. J. KENYON & CO.
(Sheet Metal Workers) LTD.
Burnden Works, Croft Lane,
BOLTON, Lancs.

Telephone: Bolton 5589

ON THE ADMIRALTY AND MINISTRY OF SUPPLY LIST.

Our extensive experience in the production of all types of OVENS for STOVING and DRYING by Convection and Infra-Red process is freely at your service.

We also specialise in Dust Extraction Systems for Polishing and Grinding operations and Wood Working machinery, Fume Extraction and Ventilating Systems, Tanks for all industrial processes, Storage, etc.

Get in touch **NOW.**

When satisfaction is demanded . . .

. . . there can be no other choice, for 3M Coated Abrasives produce smoother finishes faster and more economically. From grinding large castings to precision finishing intricate parts, there's a 3M Abrasive to do the job.

The 3M Company invite you to visit their Demonstration Rooms in London, Birmingham or Manchester, where you may select the right 3M Abrasive for your particular operation.

We recommend:—

- "THREE-M-ITE" for grinding and finishing ferrous metals.
- "THREE-M-ITE" RESIN BOND for rapid stock removal and tough jobs.
- "TRI-M-ITE" or "THREE-M-ITE" RESINITE for work on non-ferrous metals.
- "WETORDRY" cloth belts where heat generation, warping, distortion and discolourisation are liable to occur.

ABRASIVE PRODUCTS BY 3M COMPANY

TRADE MARK

MINNESOTA MINING & MANUFACTURING COMPANY LTD.

ARDEN ROAD, ADDERLEY PARK, BIRMINGHAM 8

167, Strand, London, W.C.2.

16, Mosley Street, Manchester 2.

WE SHAPE THE THINGS TO COME

We are proud to have been entrusted for many years with prototype, research and experimental work from Britain's leading aircraft and automobile manufacturers. We employ none but the finest craftsmen and are recognised as being amongst the foremost specialists in sheet metal manipulation in the country.

Experts in high class shape panel work, aircraft fabrications and assemblies.

A.I.D. & A.R.B. APPROVED

ABBEY

PANEL & SHEET METAL CO. LTD.

OLD CHURCH ROAD,
LITTLE HEATH,
COVENTRY
Tel.: COV 88217

BRO...
SMITH
FLOMASTER

Make your mark with Flo-master

THE BRITISH MADE

FOUNTnBRUSH

IT MARKS ON *ANY* SURFACE

HESSIAN PLASTIC METALS etc.

Send for illustrated leaflet.

CUSHMAN & DENISON CO., LTD.
DEPT. P., 124 VASSALL ROAD, LONDON, S.W.9
Telephone: RELiance 4172

EVERYTHING UNDER *Control*

Judgment, skill and specialised experience do make a wonderful difference! Look, for example, at the outstandingly efficient control, whether automatic or remote, that you get with Magnetic Valves—control of water, steam, coal gas, oil, air and other industrial liquids and gases; and without the aid of glands, stuffing-boxes or driving-shafts. In our illustrated catalogue you will find the full range of Magnetic Valves, up to 12″ orifice.

SPECIAL VALVES DESIGNED if required
STANDARD VALVES DELIVERED ex stock

MAGNETIC "R" TYPE SINGLE BEAT STOP VALVE

The standard valveis provided with ¼″, ⅜″, or ½″ B.S.P.T. Connections and 3/32″ orifice (5/32″ seat diameter) to operate on pressures up to 100 lbs. per square inch. As increased size orifice can be arranged dependent upon the pressure to be controlled. This valve is suitable for controlling water, air, oil, gas, refrigerants, etc., and is adaptable to either straight or angle pattern.

THE
magnetic valve co.
LIMITED
28, ST. JAMES'S PLACE, LONDON, S.W.1
Telephone: HYDe Park 7588

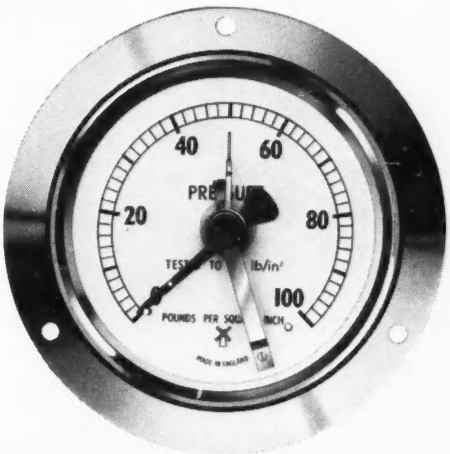
Single or Double Electric Contacts

Many different types of single and double adjustable contact gauges are manufactured to suit most applications. Brass case, with or without flange, or also flush panel mounting.
Available for a wide range of Pressures.

When you think of Pressure Gauges, think of P. & G.

Illustrated Catalogue No. 52 gladly sent on request.

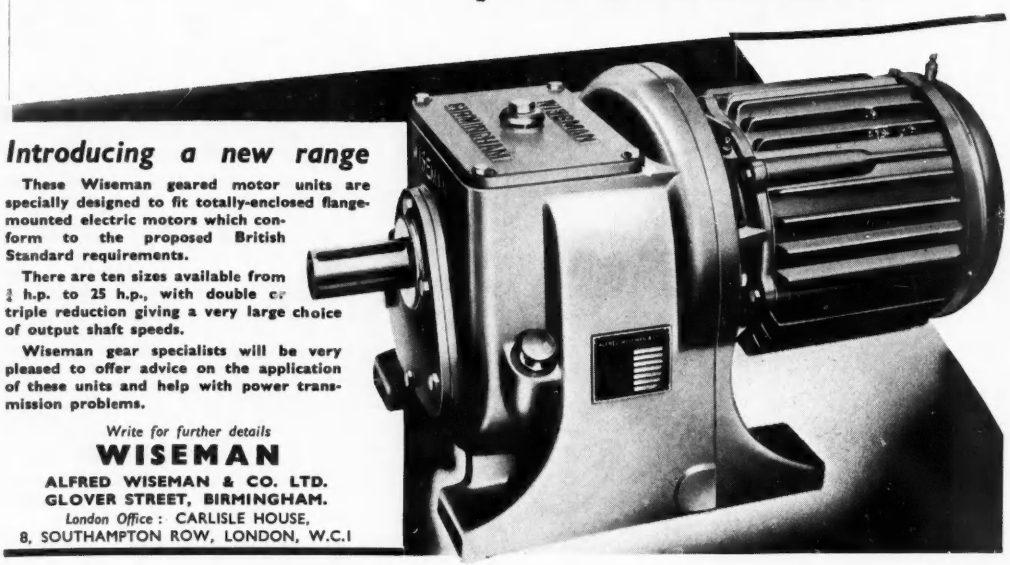
WINDMILL



PAYNE & GRIFFITHS LIMITED · TUDOR WORKS · WINDMILL LANE · SMETHWICK · BIRMINGHAM

SM/PG1040/26

Geared motor units by WISEMAN



Introducing a new range

These Wiseman geared motor units are specially designed to fit totally-enclosed flange-mounted electric motors which conform to the proposed British Standard requirements.

There are ten sizes available from ¾ h.p. to 25 h.p., with double or triple reduction giving a very large choice of output shaft speeds.

Wiseman gear specialists will be very pleased to offer advice on the application of these units and help with power transmission problems.

Write for further details

WISEMAN

ALFRED WISEMAN & CO. LTD.
GLOVER STREET, BIRMINGHAM.
London Office: CARLISLE HOUSE,
8, SOUTHAMPTON ROW, LONDON, W.C.1

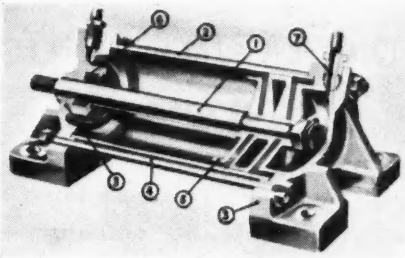
PRESSURE DIE CAST IN MAZAC ZINC BASE ALLOY TO B.S.S. 1004.

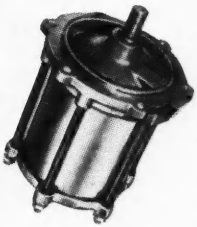
ALL SLOTS AND DOWELS CAST IN PLACE, AS ILLUSTRATED.

SIZE APPROX. 12″ × 4½″ × 0·045″ THICK.

WOLVERHAMPTON DIE-CASTING CO. LTD.
GRAISELEY HILL • WOLVERHAMPTON
TELEPHONE: 23831/4 WOLVERHAMPTON. TELEGRAMS: DIECASTINGS, WOLVERHAMPTON

AMERICAN AFFILIATION: **PRECISION CASTINGS CO. INC. FAYETTEVILLE, SYRACUSE, CLEVELAND, KALAMAZOO, CHICAGO**





Our new catalogue will keep you up to date on the most recent advances in Pneumatic Control equipment.

TECHNICAL DATA FOR DESIGNERS & WORKS ENGINEERS

Cylinders

FOR PNEUMATIC CONTROL

Cylinders are probably one of the most important units in any Pneumatic Control system, a fact which is emphasized in Lang Pneumatic design. Precision made piston Rods, cylinders of heavy gauge solid drawn copper tube, pressure tested gun-metal cylinder covers, pre-stressed tie rods secured by anti-vibration nuts, specially designed piston assembly, giving perfect seal on cylinder walls, dual piston rod seals ensuring trouble-free operation, quick assembly standard B.S.P. nuts and pipe connections.

Quality, Service & Quick Delivery

LANG PNEUMATIC *Limited*

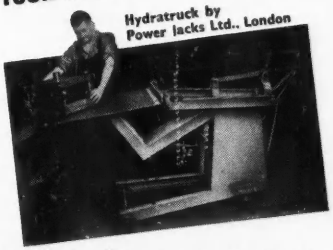
VICTORY WORKS, BIRMINGHAM RD, WOLVERHAMPTON
Tel.: 25221-2-3

All **POWERED** BY **POWER JACKS**

Hydraulic **LIFTING EQUIPMENT**
HAND OR ELECTRICALLY OPERATED

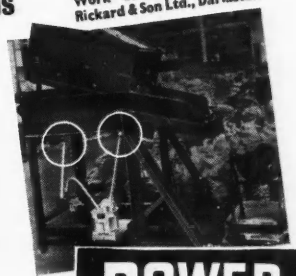
BRING YOUR HYDRAULIC PROBLEMS TO US

Hydratruck by Power Jacks Ltd., London



Battery Elevating Truck by Harboro' Construction Market Harboro'

Work Container by Chas. Rickard & Son Ltd., Darlaston



A MEMBER OF THE NEWTON GROUP

The above illustrations are typical of the wide application of Power Jacks Hydraulic Equipment to lifting and handling problems. Our Technical Advice Service is at your disposal.

Send for illustrated technical brochure. **Pub. No. 223. J**

POWER JACKS *LIMITED*

VALETTA RD. · ACTON LONDON W.3
TEL: SHEPHERDS BUSH 3443 (4 lines) GRAMS: NEWSORBER EALUX LONDON

1046

WHY ON EARTH DON'T THEY USE **OZALID?**

It is easy to understand why people, once having seen an OZALID print, make the inevitable comparisons—the quality is unmistakable.

OZALID is a dry printing process and from the moment it leaves the developing unit every copy is clean, perfectly flat, and clear in every detail.

The process of continuous reproduction is of course the quickest, cleanest and most economical in existence.

Dry Developed
PLAN PRINTING PROCESS

OZALID COMPANY LIMITED
62 LONDON WALL, LONDON, E.C.2. Tel. MONarch 9321 (8 lines)

OZALID PRINTS THE BEST

The NEW
Extra Sensitive
VPN Machine

An important advance in the design of the Vickers Hardness Testing Machine has carried a stage further the accurate determination of the hardness of metals. Materials of extremely thin section are now in common use and the highest degree of sensitivity at light loadings has become essential. This has been achieved by a new knife edge unit and simple lever mechanism which ensures that loads are truly proportional down to one kilo.
This new development in hardness determination is as important as the introduction by Vickers of the 136° pyramidal diamond indentor which resulted in VPN being universally accepted as standard.

VICKERS-ARMSTRONGS LIMITED
13 City Road · London · E.C.1 · Telephone: METropolitan 8877 · 'Grams: Vicksbox, Ave., London

CH.47

AMMUNITION FOR INDUSTRY

Rainville supply all types of cutting and welding equipment (besides the famous 'Beryl' F.H.P. motors, grinders, polishers, etc.) These BGT cutting and heating nozzles shown here are a few from a complete range of all types: annulus and splined (self-centering) nozzles for acetylene, propane or hydrogen.

BGT NOZZLES AND CUTTERS

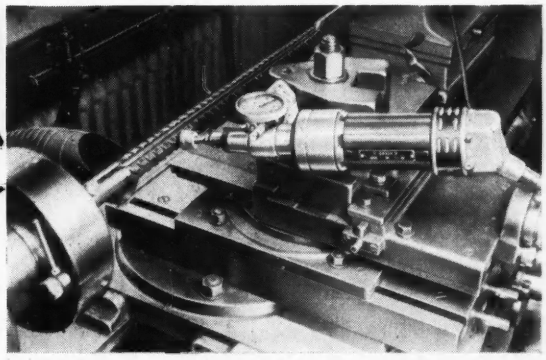
RAINVILLE ENGINEERING CO. LTD.

Downshire House, Roehampton Lane, London, S.W.15. PUTney 7742

Branches: Birmingham, Glasgow, Lymington (Hants), Manchester, Sunderland, Sheffield, Thornaby-on-Tees, London (56, Lymington Road, N.W.6)

BOSCH

UNIVERSAL ELECTRIC TOOLS



Grinding a screw tap by means of support grinder using the Bosch adjustable holder with dial indicator

THE FULL RANGE OF THESE FAMOUS TOOLS INCLUDES:—
Hand Motors
Drills
Grinders
Screwdrivers
Nut Runners
Tappers
Shears
Nibblers
Polishers

A 24,000 r.p.m. universal grinder type EW/US65A1 for hand operation or with tool support as illustrated. The no-play bearing spindle makes this the ideal tool for the precision grinding of steel, iron, non-ferrous metals, ceramics and for milling wood in pattern making. Entirely suitable for use with tungsten carbide cutters.

Write for full particulars

SOLE DISTRIBUTORS IN THE U.K.

N.A.E.S. Ltd

KNOLL ST. HIGHER BROUGHTON. MANCHESTER 7.
TELEPHONE: BROUGHTON 2213 (5 LINES)
TELEGRAMS: NORAUTELEC MANCHESTER

Bowden

HIGH PRESSURE HOSE UNITS

with

Re-usable End Fittings

(World patents applied for)

enable users to replace defective hose in a few minutes and at a fraction of the cost of a new unit. These fittings make possible the repair of many internally wire-braided hose assemblies, provided they will stand shortening. Send us your defective units for examination.

BOWDEN (Engineers) LTD.
Willesden Junction
London, N.W.10

Bowden also manufacture the World's best wire control mechanisms, backed by 56 years' experience

48-141

TEMPERATURE MEASUREMENT

"Thermindex" Paints are temperature sensitive compounds which indicate by a sharp, clear cut change of colour when the temperature of a surface has attained or exceeded a predetermined value, so that information on the temperature of an entire surface is given at a glance.

Write Dept. H/14 for full technical details.

"THERMINDEX"
TEMPERATURE INDICATING PAINTS

SOLE DISTRIBUTORS FOR EUROPE AND THE U.K.

J. M. STEEL & CO. LTD
36-38 KINGSWAY, LONDON, W.C.2.
Tel, HOLborn 2532/5

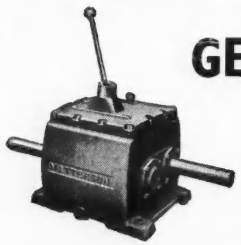
Branch Offices:

51 SOUTH KING ST., MANCHESTER 2
Tel. : Deansgate 6077/9.

45 NEWHALL ST., BIRMINGHAM 3
Tel.: Central 6342/3.

Manufactured by Synthetic & Industrial Finishes Ltd.

GEARBOXES

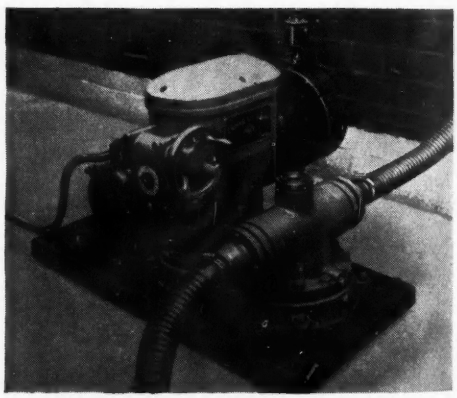


2, 3, 4, 6 & VARIABLE SPEED

Made mainly from batch produced parts Matterson Gearboxes are completely reliable and reasonably priced. The units are built in 2, 3, 4 and 6 speed and infinitely variable models by men taking a pride in their work. They will not let you down.

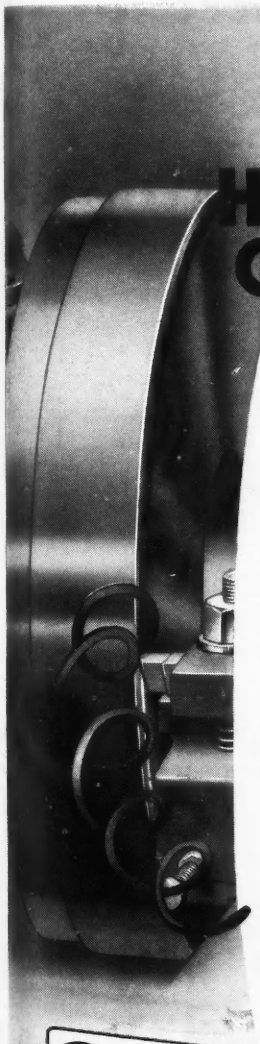
MATTERSON LIMITED
SHAWCLOUGH · ROCHDALE
Tel. 4194

THE
SIMPULSIC PUMP



Here is an entirely new variable capacity pump specially designed for handling acids, alkalies, slurries, viscous fluids, and other difficult liquids. It has no glands and all passages and valves are of special chemical resisting rubber. The output can be varied whilst the pump is running. Your enquiries are invited.

AMES CROSTA MILLS & Co. Ltd.
HEYWOOD LANCS
London Office : Abbey House, Victoria Street, S.W.1



. . . for

HEAVY CUTS on TOUGH STEELS

Try 'Eclipse' Tool Bits on the tough jobs — made from H3 Cobalt High Speed Steel, melted and processed throughout in our own works, and scientifically heat-treated by us to bring out the best in it.
'Eclipse' will take amazing cuts and speeds with a really fine finish on the workpiece — fewer regrinds, too.
That's economy for you.

TOOL BITS

Made from "Eclipse" H3 Cobalt High Speed Steel

Made by James Neill & Company (Sheffield) Ltd., and obtainable through your usual supplier

TB6

BINDING CASES

for the permanent binding of your 12 monthly copies of

THE ENGINEERS' DIGEST

Volume XIV, Nos. 1—12, Jan—Dec 1953

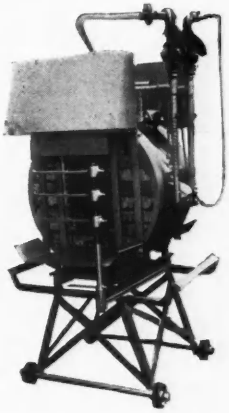
are now available. Made of strong blue cloth, they can be obtained at **10/6,** incl. postage. Please indicate if you wish to bind your copies with or without the advertisement section of the journal.

Orders should be sent to the Subscription Dept.,

"THE ENGINEERS' DIGEST"

120 WIGMORE STREET, LONDON, W.1.

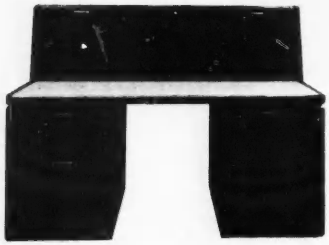
THIS GAS FURNACE IS A REAL FUEL SAVER



Up to 30% reduction in gas consumption reported by present users

Write for full details and specifications

DAVID ETCHELLS & SON LTD.
BULL PIECE WORKS
DARLASTON S. STAFFS

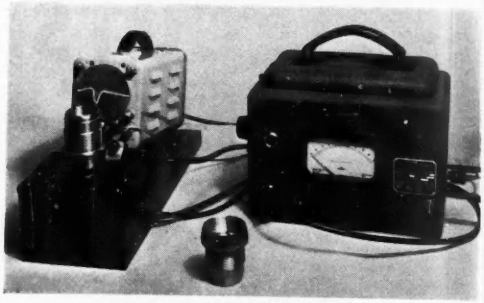


We manufacture
a wide range of metal cabinets
cases, racks and desks
for use in many branches of industry
We also design and make
special metal housings for those
whose requirements are not met
by our standard range

IMHOFS

Alfred Imhof Ltd., 112-116 New Oxford St. W.C.1. Mus. 7878

Cornelius Electronic Comparators



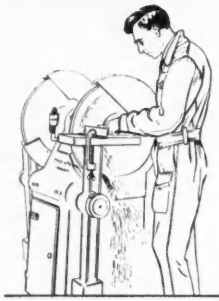
HIGH SPEED CRACK DETECTION

CORNELIUS ELECTRONIC INSTRUMENTS LIMITED

90 Broadway Coventry England

COATED ABRASIVES BY

OAKEY



IN DISCS, BELTS AND ROLLS

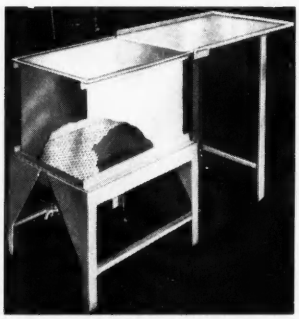
FOR ALL ENGINEERING TRADES

JOHN OAKEY & SONS LIMITED

WELLINGTON MILLS, LONDON, S.E.1

NEW! **DE-WATERING PLANT**

essential anti-rust equipment



Do you realise that RUST will reduce your profits unless you take instant action! Install this De-watering Plant so that every component can be treated *immediately*. Just dip and all moisture is instantly thrown off and replaced with lanolin-rich solution. Plant can be operated by unskilled labour.

PRICE ONLY

£19. 15. 0

plus 5% at our works

Send for literature

DE WATERING FLUIDS Solvent type anti-rust fluid sold in 40-gal. barrels and 5 & 10 gal. drums.

TOOL TREATMENTS (CHEMICALS) LTD

PLANTS – EQUIPMENT – OUTWORKERS

CHEMICAL BLACK, DE-WATERING, DE-GREASING

COLLIERY ROAD – BIRMINGHAM ROAD

WEST BROMWICH, Staffs. phone 1618

MACROME LIMITED

Appointed **EXCLUSIVE** **SALES MANAGERS** for BRENCO REGD. TRADE MARK HAND TOOLS

Macrome Limited have pleasure in announcing their appointment as Exclusive Sales Managers for the Hand Tool Division of the Bren Manufacturing Company Limited, Gateshead 11. Brenco Chrome Vanadium Hand Tools include Ring Wrenches, Open Ended Spanners, Combination Spanners and Sockets in Whitworth, B.S.F., American, Metric and Unified sizes.

IN FUTURE, THEREFORE, ALL ENQUIRIES concerning Brenco Hand Tools should be sent to Macrome Limited at Aldersley, Wolverhampton, where comprehensive stocks are held, or to any of the Macrome Branches in London, Manchester or Glasgow.

Brenco Spanners and Wrenches are guaranteed unbreakable

Issued by
MACROME LTD., ALDERSLEY, WOLVERHAMPTON. Tel.: 52001 (5 lines)

WhiteAd 2723

Magnetic Chucks

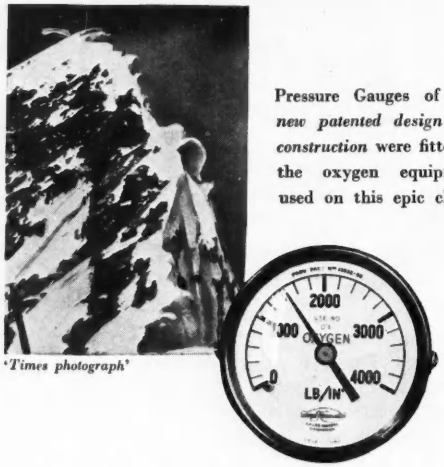
in standard sizes or to your own specification.

Our catalogue will help you select a type and size of chuck most suitable to your needs.

Write for your copy today.

J. H. HUMPHREYS & SONS, BLACKRIDING ELECTRICAL WORKS, WERNETH, OLDHAM. Phone: MAI 1651

The Ascent of Everest . . .



'Times photograph'

Pressure Gauges of our *new patented design and construction* were fitted to the oxygen equipment used on this epic climb.

DAVID HARCOURT LTD

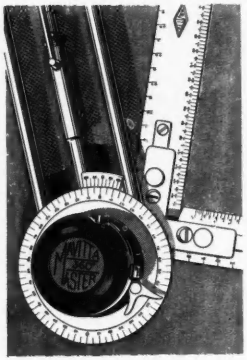
LINKULA WORKS · COVENTRY RD · BIRMINGHAM 10
Telephone: Victoria 1051-1052 *Telegrams: Linkula Birmingham 10*

a member of SMITHS *Industrial Instrument Division*

252/10

MAVITTA
DRAFTING MACHINES

A complete range of Drafting Machines for Boards up to 50 feet long, both vertical and horizontal.
Adjustable Drawing Stands and Boards.
Mathematical Scales in various materials.
Surveyor's Rods. Isometric Projection Machines



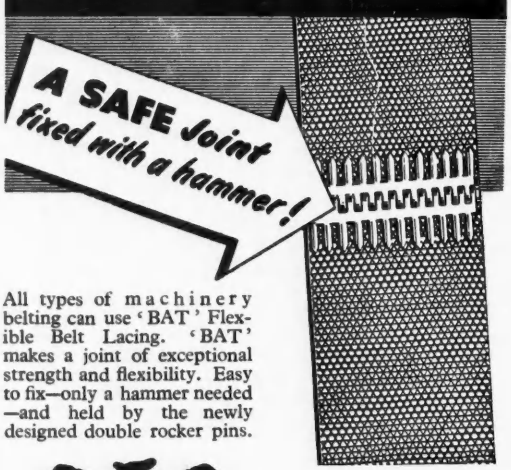
THE MASTER—latest in our range—Linkage by steel bands and pulleys —360 degrees rotation of index head—automatic location of main angles by press button through knob—quick release of head for lining up to drawings—counter balanced for vertical use —modern styling and high quality finish.

FULL CATALOGUE ON APPLICATION

The MAVITTA DRAFTING MACHINES LTD.
HIGHLANDS ROAD · SHIRLEY · BIRMINGHAM
Phone: SOLIHULL 2231/2 Grams: Mavitta, B'ham

MIA

FOR MACHINERY BELTS



All types of machinery belting can use 'BAT' Flexible Belt Lacing. 'BAT' makes a joint of exceptional strength and flexibility. Easy to fix—only a hammer needed —and held by the newly designed double rocker pins.

A.P.8

BAT BRAND

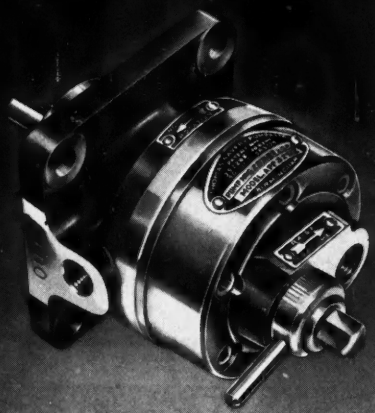
FLEXIBLE BELT LACING

AUTOMATIC PRESSINGS LTD., Bat Works, Blackheath, Staffs.
Makers of 'BAT' Carded Belt Hooks and Timber Connector

Please mention 'Engineers' Digest'.

THE THOMAS SAVERY PUMP

FIXED, OR VARIABLE DELIVERY
WILL SOLVE ALL YOUR PROBLEMS ON HYDRAULIC CONTROL OF MACHINE TOOLS



USED BY ALL LEADING MACHINE TOOL AND OIL BURNER MANUFACTURERS
SPECIALISTS IN METERING PUMPS
THOMAS SAVERY PUMPS LTD.
BRACEBRIDGE STREET, BIRMINGHAM, 6. Telephone: ASTON CROSS 1348-9

"I rely on Charles Clifford for RODS"

FLAT—ROUND—HEXAGONAL—SQUARE in

NON-FERROUS METALS

Phosphor Bronze, Gun Metal, Aluminium Bronze, Naval Brass, Copper, Brass, Zinc etc.

. . . and numerous Alloys for specific purposes and to British Standard Specifications.

Chas Clifford Birmingham

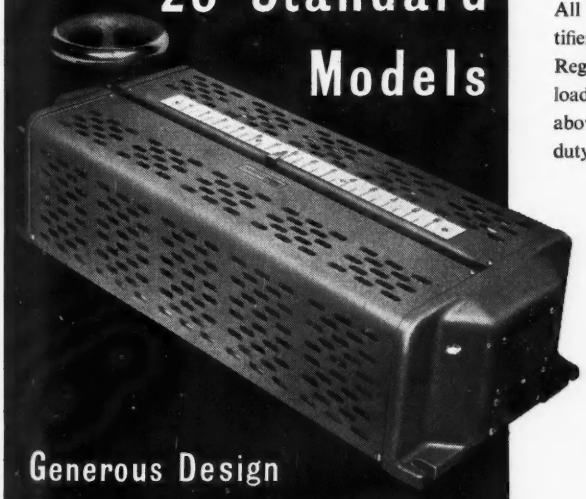
CHARLES CLIFFORD LIMITED

Dog Pool Mills, Birmingham 30
and
Fazeley St. Mills, Birmingham 5

Specialists in the production of Wrought High Tensile Alloys

M-W.101

26 Standard Models



Generous Design
Robust Construction
Rugged Self-lubricating Brushes

All types of A.C. apparatus—motors, furnaces, rectifiers, transformers—can be controlled by a single Regavolt whose output can be set, regardless of the load current, precisely at any voltage from 0 to 30% above the supply. Its rugged design for heavy industrial duty ensures reliability under severe working conditions.

Special designs can be made for incorporation in your own apparatus in addition to the wide range of single, 3 phase, hand and motor driven models listed in our catalogue No. 3121.

BERCO

REGAVOLT
REGULATING
TRANSFORMER

THE BRITISH ELECTRIC RESISTANCE CO. LTD.
Specialists in the control of current and voltage for more than 25 years.
Queensway, Ponders End, Middlesex
Telephone: HOWard 1492 Telegrams: Vitrohm, Enfield

BR.3121

HARD CHROME PLATING

HEAVY DEPOSITION

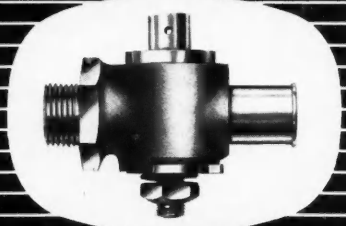
Metal Processing is our business and to cover this trade efficiently in all its aspects our works are equipped to undertake the treatment of materials up to 6 tons in weight. Our technicians are always at your service.

Please send us your enquiries.

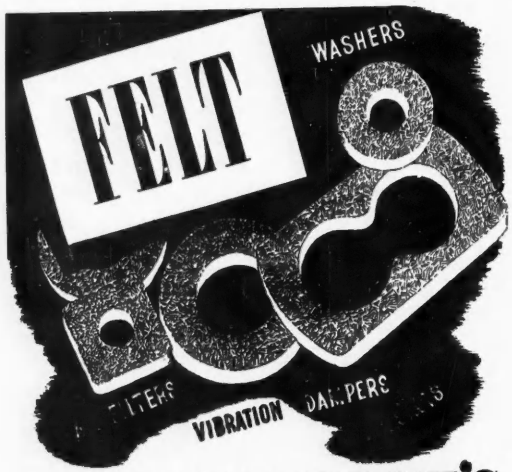
Heavy goods can be delivered right into our works either by rail road.

ELECTRO-PLATERS
LIMITED
68 BROCKVILLE ST., CARNTYNE, GLASGOW
TELEPHONE: SHETTLESTON 3491 4 LINES

COCKS AND MACHINED PARTS
FOR THE ENGINEERING AND KINDRED TRADES
SUITABLE FOR HEATING AND LUBRICATING SYSTEMS ETC
Superlative Quality

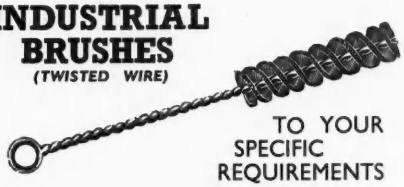


FOR A GUARANTEED JOB... *contact...*
Wm. WHITEHOUSE & CO. LTD
BRUETON STREET • BIRMINGHAM 4
ESTABLISHED OVER 70 YEARS



RAWSTHORNE'S
(Bolton) Limited
BULLOCK STREET WORKS, BOLTON.
Telephone: 1143 *Established 1860*

INDUSTRIAL BRUSHES
(TWISTED WIRE)



TO YOUR SPECIFIC REQUIREMENTS

Twisted wire core brushes for either hand or motorised operation can be supplied promptly with fillings of :
WIRE, BRISTLE OR NYLON
also
WOOL MOPS

Your enquiries will be welcomed

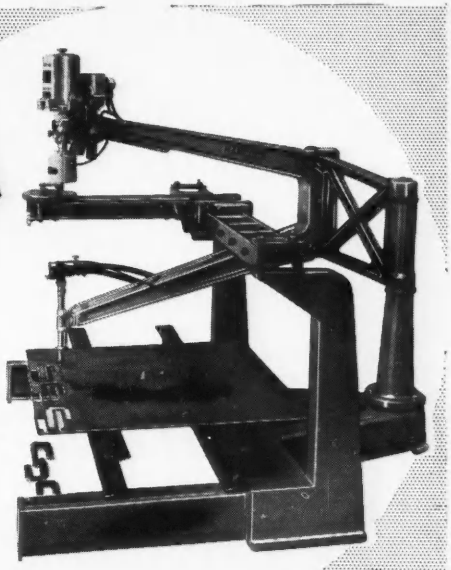
Descriptive literature free on request

Parker-Hale LIMITED

Bisley Works
Tel.: CEN. 7637-8 BIRMINGHAM 4.

HANCOMASTER

The NEW general-purpose profiling machine



- **Supersedes the famous Hancock "U" Arm Profiler.**
- **Speeds up and simplifies oxygen cutting.**
- **Increases output of small parts by 50 per cent.**
- **Has movable template carriers for easy control.**

This latest edition to the HANCOCK range of versatile oxygen cutting machines combines equal facility for rapid production work with easy and convenient methods of obtaining one-off. Write for illustrated folder today.

HANCOCK & CO. (Engineers) **LTD.**
PROGRESS WAY, CROYDON, ENGLAND Telephone: CROYDON 1908 (PBX)

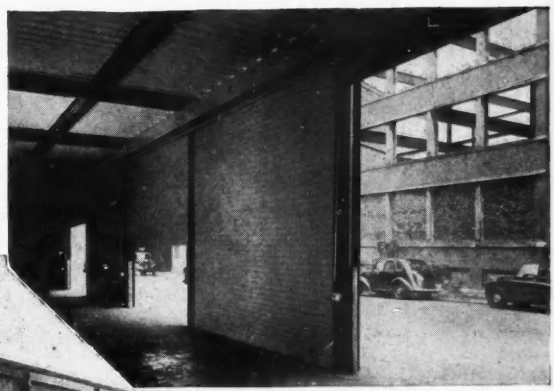
HANCOCK CUTTING MACHINES

For Large Openings

BOOTH

WEATHERPROOF STEEL

ROLLING SHUTTERS



Photos show part of a range of six Booth Steel Rolling Shutters varying in height from 16 ft. 8½ ins. to 15 ft. 1½ ins. Six shutters are 19 ft. 4 ins. wide and one is 13 ft. 8¾ ins. The top photo shows the clear unobstructed floor space which is obtained by the overhead storage of rolling shutters.

Illustrated Catalogue on request.

JOHN BOOTH & SONS (BOLTON) LTD., Fireproof Door and Shutter Dept.
Telephone 1195. **HULTON STEELWORKS, BOLTON.** Cables: "Irony," Bolton. Code: Bentleys, A.B.C. 5th Edition.
LONDON: 26, VICTORIA STREET, WESTMINSTER, S.W.1. Telephone: ABBey 7162.

CHECK YOUR COSTS!

RE-REFINE YOUR WASTE OIL WITH A LUBEX

ONE OF THE LARGEST OIL COMPANIES STATES:

"Thank you for sending us the reclaimed samples of the used detergent oil for examination. We were very impressed by the appearance of the sample"

ANOTHER OIL COMPANY STATES:

"Your name has been circulated to our senior engineers for use in their dealings with our customers, where recovery of oils is most essential"

FOLLOW THEIR LEAD, WRITE FOR DETAILS

LUBEX
OIL REFINERS

✦ ✦ ✦

48 GOWERS WALK,
COMMERCIAL ROAD,
LONDON, E.1

ROYAL 3864

EXPERIENCE COUNTS ABOVE ALL

Clayflex Flexible Bearings
stop vibration, reduce noise.

Clatonrite Anti-Vibro Levellers
fitted to plant avoid vibration.

Clayseals Oil Seals
(or Grease Retainers), all rubber moulded design.

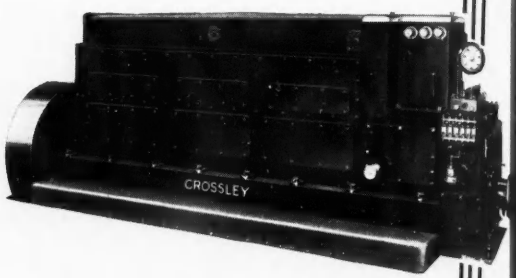
Harrisflex (Torflex) **Flexible Couplings**
Full torque. No frictional loss.

Kompolastic Super Jointing Materials
Specified by leading Companies. Supplied die punched to any given shape or size.

Stickastrip Adhesive Sponge-rubber Sealing Strip
Seals cracks, provides cushioning, gives electrical insulation.

HOWARD CLAYTON-WRIGHT LTD.
WELLESBOURNE, WARWICKSHIRE
Tel: Wellesbourne 316/7/8 **Grams: Clatonrite, Wellesbourne**

CROSSLEY



A TYPICAL CROSSLEY MULTI-CYLINDER DIESEL

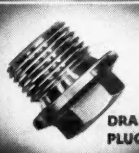
VARIOUS TYPES AND SPEEDS FROM 10 TO 1000 H.P.

CROSSLEY BROTHERS LTD OPENSHAW MANCHESTER
London Office: Langham House, 308 Regent St., W.1.

C.261

Every type of Industrial lubrication equipment readily available from stock including drain plugs, filler caps, solder and solderless fittings, brass turned parts and a wide variety of nipples and guns.

Main distributors for the **Hart** *system of centralised lubrication. Full particulars sent on request.*

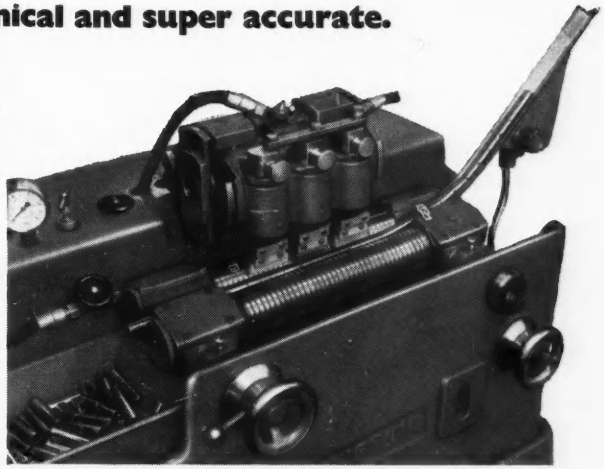


THE GREASE APPLIANCE CO. ROMILEY CHESHIRE PHONE :- WOODLEY 2836

CENTRELESS SUPER FINISH LAPPING MACHINE

A finishing process economical and super accurate.

Super finish to $\frac{1}{2}$—$\frac{3}{4}$ micro-inch from 4—7 micro inches (as ground) obtained in two passes by the S.F. centreless method—AND AT PRODUCTION RATES. Capacity up to $1\frac{1}{2}$" diameter.



Full particulars from :

CHARLES CHURCHILL & CO. LTD.

COVENTRY ROAD, SOUTH YARDLEY, BIRMINGHAM, 25

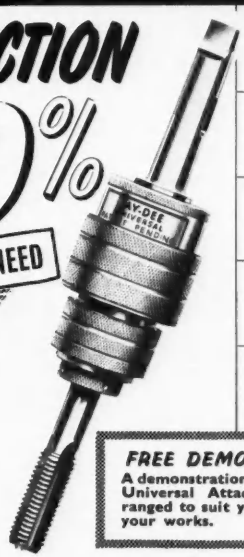
ALSO AT LONDON, MANCHESTER, GLASGOW AND NEWCASTLE-ON-TYNE

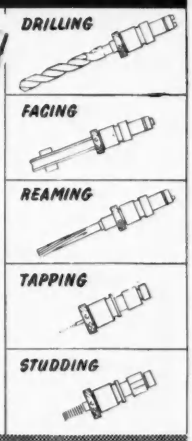
WITH THE NEW 'Jay-Dee' UNIVERSAL ATTACHMENT

you can INCREASE PRODUCTION by 50%

Split-second tool changing gives you all operations applicable to the art of drilling !

ONE SETTING IS ALL YOU NEED





The amazing "JAY-DEE" Universal Attachment saves you time, labour and money at every turn! Staying permanently in position, needing no adjustment by the operator, it carries out one perfect job after another, rapidly and safely. The "JAY-DEE" is adaptable to all drilling machines, combination lathes, turning and boring mills, and can readily undertake the duties of any three turret stations.

Write today to our nearest office for fully illustrated descriptive brochure.

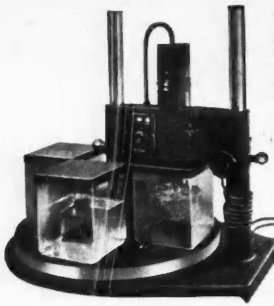
Applications are invited for agencies in the U.K.

Manchester Office: Silver Street, 253, Bury New Road, Whitefield, Manchester. Telephone: Whitefield 3332

Birmingham Office: 5, Green Lane, Great Barr, Birmingham, 22A. Telephone: Great Barr 1003

FREE DEMONSTRATION !
A demonstration of the "JAY-DEE" Universal Attachment can be arranged to suit your convenience, at your works.

Sole Distributors: A. B. & M. Engineering Limited, Greenock **Telephone: Greenock 23173**



AN ENTIRELY NEW MECHANISM CLEANER BY N.S.E.

From N.S.E. comes this new mechanism cleaner (type B/RST Series 1) for the efficient and reliable cleaning of mechanical and electrical parts. It has been designed by engineers with wide experience of the needs of the Meter and Instrument industries and among its many outstanding features are :—

- 8" diameter × 4" deep cleaning basket with removable subdivisions to enable moderately large or very small parts to be cleaned equally well.
- Removable basket and clamps to enable complete mechanisms to be cleaned as units.
- Robust construction
- Pushbutton start
- Built-in fuses
- Neon indicator lamps
- Double lip aluminium lid to prevent splash leakage
- Crackle black and chromium finish

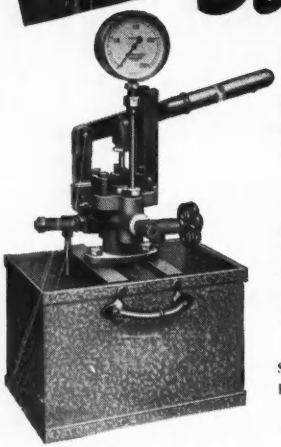
May we send you full details ?

NORTHERN SCIENTIFIC EQUIPMENT LTD., Bark Street, Bolton, Lancs. Tel.: 3588.

BA2

TEST PUMPS ?

RING Bailey's



Immediate delivery available from a wide range of sizes and types for all industrial purposes from 300 p.s.i. to 45,000 p.s.i.

Illustrated: Hand-operated concentric ram test pump, with 2 in. ram for rapid filling of vessel to be tested and ⅝ in. ram for obtaining the pressure. Suitable for pressures up to 1,500 p.s.i.

SIR W. H. BAILEY & CO. LTD
PATRICROFT · LANCASHIRE

Phone: ECCLES 3487-8-9
Grams: BEACON, PATRICROFT

LONDON OFFICE : 16 Dartmouth Street, London, S.W.1 Telephone : Whitehall 3988

SLUICE VALVES · REDUCING VALVES · TEST PUMPS · TURNSTILES

IMPORTANT ANNOUNCEMENT

on

CENTRIFUGAL PUMPS

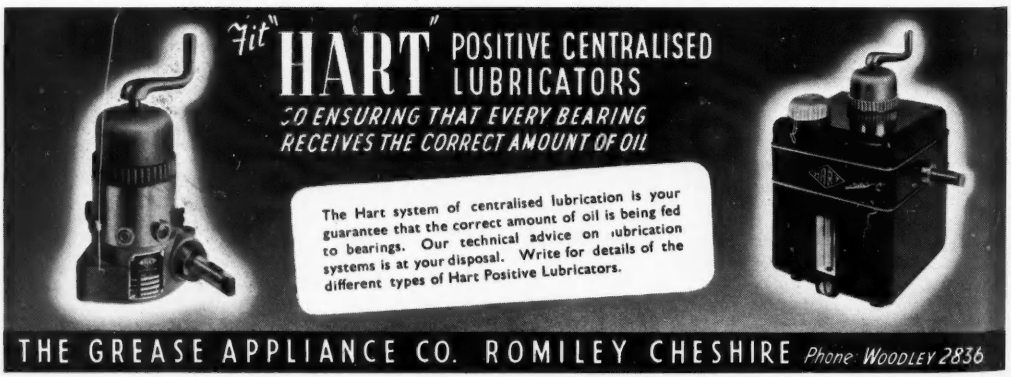
G. & A. FIRKINS LTD.

84b, DARLINGTON ST., WOLVERHAMPTON

have taken over all Sales and Service of the centrifugal pumps made by

FRANCIS WHITE (PUMPS) LTD.

following upon the reorganisation of that company.


"Fit" "HART" POSITIVE CENTRALISED LUBRICATORS
SO ENSURING THAT EVERY BEARING RECEIVES THE CORRECT AMOUNT OF OIL
The Hart system of centralised lubrication is your guarantee that the correct amount of oil is being fed to bearings. Our technical advice on lubrication systems is at your disposal. Write for details of the different types of Hart Positive Lubricators.
THE GREASE APPLIANCE CO. ROMILEY CHESHIRE Phone: WOODLEY 2836

. . . ever baked a 'bus?

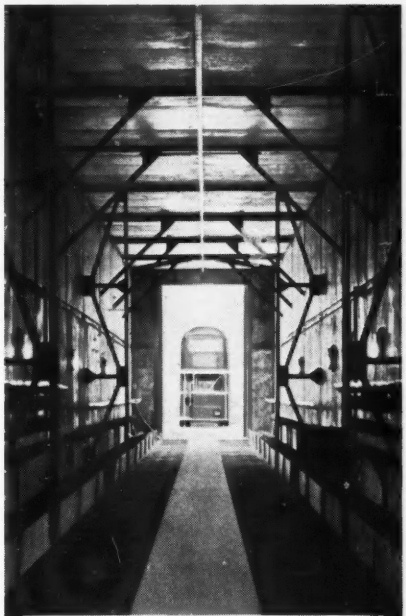
. . . the need for speed on the assembly line necessitates rapid drying techniques

. . . the application of heat (generated at considerable cost)

. . . and to conserve this heat drying ovens lined with the perfect insulant

J & B MINERAL WOOL

. . . be your problem a 'bus or thousands of small articles on a conveyor belt — there is no more economical, more adaptable or more efficient material to keep heat in its place . . . and avoid waste . .



In semi-rigid felts, J & B Mineral Wool is readily enclosed in frames, or between tin-plates, as in these demountable oven panels (illustrated by courtesy of Heat & Air Systems Ltd.)

J&B MINERAL WOOL

FIREPROOF — NON-CORROSIVE
INORGANIC — WATER REPELLENT
NON-SETTLING

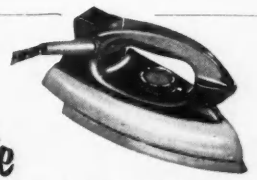
Write for Technical Data Sheets or Consult our Advisory Service Dept. S.12.

JONES & BROADBENT LTD

PERREN ST., LONDON, N.W.5. *Telephone: GULliver 2120, 5548/9*

and at Billingham-on-Tees, South Bank (Yorks), Bristol, Burton-on-Trent, Liverpool and Manchester.

A PECO 5c DIE CASTER 'ironed out' the production problems



of this sole plate

PECO machines have completely modernised the technique of Cold Chamber Pressure Die-Casting and with their unique feature, an electrical control, they are considerably in advance of other machines on the market. Four core-pulling connections, hydraulic ejection cylinder and bumper bars for mechanical ejection are fully interlocked, permitting operation in any sequence.

Illustrated literature on the 2c and 10c Die-Casting Machines will gladly be sent on request.

These sole plates are being produced by the BRITISH DIE-CASTING COMPANY for MORPHY-RICHARDS, LTD. The main illustration is of the production of these castings completely carried out on the PECO 5c Die-Caster.

PECO PRODUCTS

THE PROJECTILE & ENGINEERING CO., LTD.

ACRE STREET, BATTERSEA, LONDON, S.W.8, ENGLAND

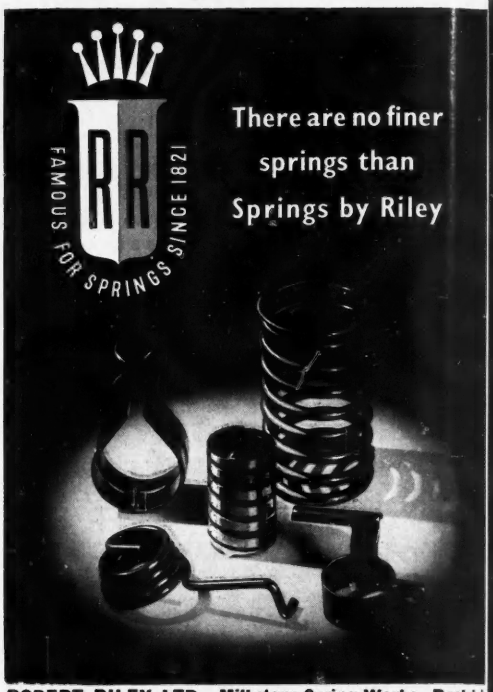
Telephone: Macaulay 1212 Telegrams: "Profectus, Claproad, London" Cables: Profectus, London.

PIC SLIDE RULES

Ensure maximum efficiency with minimum of scale length over the most comprehensive range of calculations. No other slide rule—British or Foreign—offers the same or equal advantages.

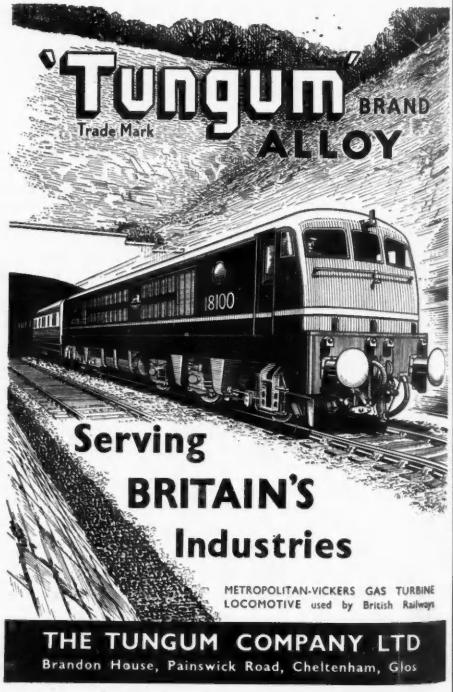
Our Illustrated Catalogue giving particulars of P.I.C. Slide Rules, Drawing Instruments, etc., is sent Post Free on request.

A. G. THORNTON LTD
Drawing Instrument Specialists
WYTHENSHAWE, MANCHESTER.
L7A



ROBERT RILEY LTD., Milkstone Spring Works, Rochdale
Phone: Rochdale 2237 (5 lines) Grams: 'Rilospring' ROCHDALE

KEETON, SONS & CO. LTD.,
ROYDS LANE, SHEFFIELD, 4
TEL: SHEFFIELD 24738



THE TUNGUM COMPANY LTD
Brandon House, Painswick Road, Cheltenham, Glos

Pressure

DIECASTINGS

up to 3½ lbs

in

MAZAK ZINC ALLOY

to B.S. 1004A.

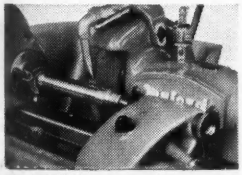
Let us place 20 years experience in Zinc Alloys at your service.

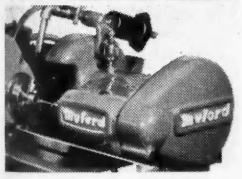
WESTERN DIECASTING LTD.

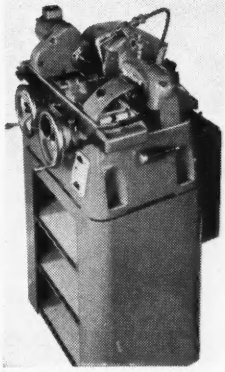
12-44 PHOENIX STREET, BARTON HILL, BRISTOL 5. Phone: Bristol 56593

ZADCA

A member of the Zinc Alloy Die Casters Association.







MG9 GRINDER

A relatively low-priced machine for cylindrical and internal grinding. Available as a plain cylindrical grinder or with additional internal grinding equipment.

Work Swing 5" dia. **Between Centres 9"**

Dial Reading ·0001" **Fine Feed ·00005"**

Send for Publication 901

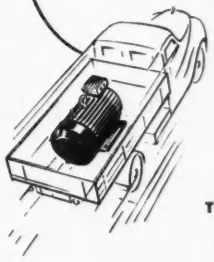
MYFORD

BEESTON · NOTTINGHAM · ENGLAND

Get in touch with the nearest L.D.C. office for immediate attention to your requirements. The full resources of the Company are at your disposal and experienced Technical Engineers, at all branches, will gladly give their assistance and advice.

Phone our Local Office

Birmingham Midland 2261 **Bristol** 24458
Cardiff 27869 **Glasgow** Central 3983
Leeds 2-0407 **London** Whitehall 7211
Manchester Blackfriars 7865
Newcastle 28621 **Nottingham** 52682
Sheffield 50565.



Send Today
FOR STOCK & PRICE LIST
of Screen-Protected and "Fankuld" (T.E. Fan-cooled Motors) up to 60 h.p. 400/440 V. 50 Cy. 3 Phase.

The Symbol of Power in Industry for over 50 years

LDC LANCASHIRE CRYPTO

LANCASHIRE DYNAMO & CRYPTO LTD

TRAFFORD PARK MANCHESTER 17
'Phone: TRAfford Park 2161 6

ACTON LANE WILLESDEN LONDON N.W.10
'Phone: ELGar 7744/51

London & Export Offices:
ST. STEPHEN'S HOUSE, VICTORIA EMBANKMENT, WESTMINSTER S.W.1. *'Phone:* WHitehall 7211 6

F/6

H. FORDSMITH LIMITED

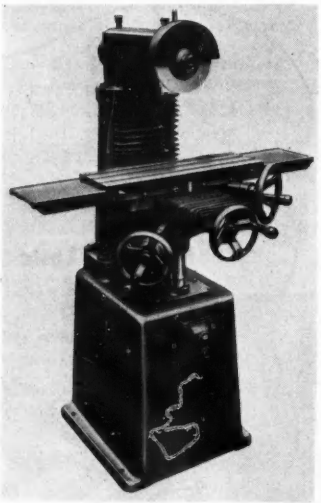
HADFIELD STREET WORKS · CORNBROOK · MANCHESTER
TRAfford Park 1615-6

'EAGLE' SURFACE GRINDER

18" × 6" TABLE
15" × 6" CAPACITY

The ideal machine for

Production,
Tools,
Assembly,
Dies,
Fitting,
Toolmaking,



QUICK DELIVERY

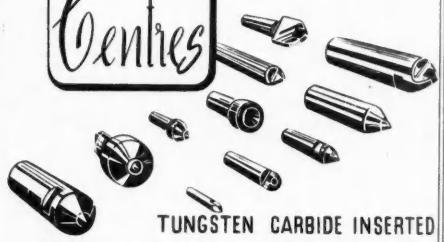
PRICE £140

VICTA ENGINEERING Co.

OFFICES: THICKET CORNER, MAIDENHEAD

PAREX Centres

ESTABLISHED 1923



TUNGSTEN CARBIDE INSERTED

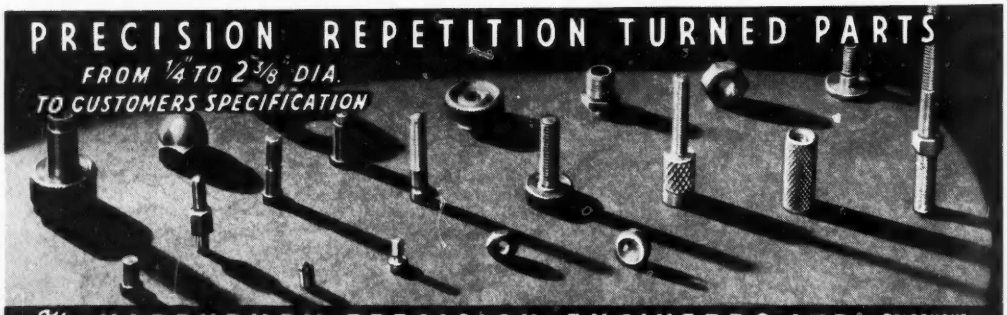
They are Tough and Hard and outlast many H.S. Steel or "Live" Centres. "PAREX" means accuracy with economy. They are supplied in all standard tapers, or specials for light or heavy duty lathes and grinding machines. "PAREX" metal is not affected by ordinary abrasive grits. Send for price lists and literature to Sole Makers:

ERNEST TURNER & Co. (SALFORD) LTD.

"Parex" Works, West Burton Street, Salford, 5.
Tel. Tra. Park 1381.

PRECISION REPETITION TURNED PARTS

FROM 1/4" TO 2 3/8" DIA.
TO CUSTOMERS SPECIFICATION



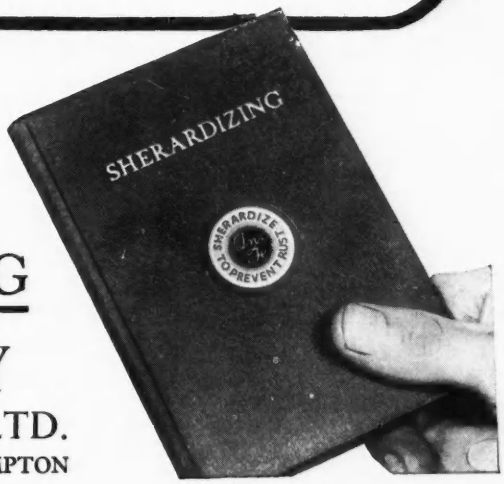
The HARPURHEY PRECISION ENGINEERS LTD. TELEPHONE - MIDDLETON 3681-2

EMPIRE WORKS · MOSTON ROAD · MIDDLETON · MANCHESTER

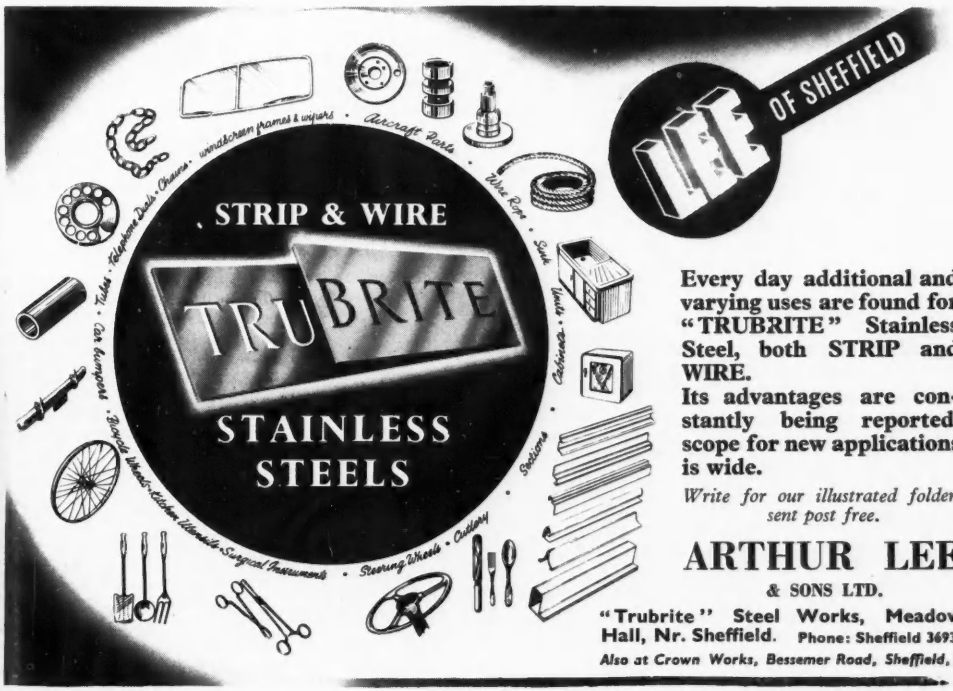
YOURS *for the Asking*

LEARN HOW TO:—
SPECIFY,
TEST,
USE,

SHERARDIZING



ZINC ALLOY
RUST PROOFING CO. LTD.
SHAKESPEARE STREET, WOLVERHAMPTON
TELEPHONE: WOLVERHAMPTON 20647/8
ALSO AT LONDON & ROCHDALE



Every day additional and varying uses are found for "TRUBRITE" Stainless Steel, both STRIP and WIRE.
Its advantages are constantly being reported, scope for new applications is wide.

Write for our illustrated folder, sent post free.

ARTHUR LEE
& SONS LTD.
"Trubrite" Steel Works, Meadow Hall, Nr. Sheffield. **Phone: Sheffield 36931**
Also at Crown Works, Bessemer Road, Sheffield, 9

Index to Advertisers and their Advertising Agencies

A.B. & M. Engineering Co., Ltd.....A91
Agency—Alfred Bates & Son, Ltd.
Abbey Panel & Sheet Metal Co., Ltd..A76
Abrasive Developments Ltd.....—
Acru Electric Tool Mfg. Co., Ltd.....—
Allspeeds Ltd.....—
Agency—Hyde & Ptnrs. Ltd.
Ames Crosta Mills Ltd.....A82
Agency—Arthur Burns Publicity.
Angus, Geo. & Co., Ltd.....A22
Agency—Redheads Advertising Ltd.
Archdale, James & Co., Ltd.....A30
Automatic Coil Winder & Electrical Equipment Co., Ltd.....A71
Agency—National Publicity Co., Ltd.
Automatic Pressings Ltd.....A86
Agency—John Haddon & Co., Ltd.

B.S.A. Tools Ltd.....cover 4
Bailey, Sir W. H. & Co., Ltd.....A92
Agency—Technical & General Adv. Agency Ltd.
Beakbane, Hy., Ltd.....A51
Benton & Stone Ltd.....A43
Agency—H. C. Longley Ltd.
Birlec Ltd.....—
Agency—Sandbrook, Metcalf & Co., Ltd.
Booth, James & Co., Ltd.....A26
Agency—Technical & General Adv. Agency Ltd.
Booth, John & Sons (Bolton) Ltd.....A89
Agency—Commercial Adv. Service Ltd.
Bowden (Engineers) Ltd.....A82
Agency—Allardyce Palmer Ltd.
Brady, G. & Co., Ltd.....A32
Agency—Stowe & Bowden Ltd.
Brammer, H. & Co., Ltd.....—
Agency—Heslock Ltd.
Briscoe, W. H. & Co., Ltd.....—
Agency—A. N. Holden & Co., Ltd.
Bristol's Instrument Co., Ltd.....—
Agency—Glovers Advertising Ltd.
British Cutting Gases Ltd.....A81
Agency—Crossley & Co., Ltd.
British Driver Harris Co., Ltd.....—
Agency—Harry Dawson Advertising.
British Electric Resistance Co., Ltd...A87
Agency—Dorland Advertising Ltd.
British Electrical Development Assn..A69
Agency—Mather & Crowther Ltd.
British Insulated Callender's Cables Ltd.....—
Agency—R. F. White & Son, Ltd.
British Oxygen Co., Ltd.....A2 & A3
Agency—Basil Butler Co., Ltd.
British Rolling Mills Ltd.....—
Agency—Maurice G. Parker Ltd.
British Thomson-Houston Co., Ltd....—
British Timken Ltd.....A60
Agency—H. Raymond Morgan.
Brookhirst Switchgear Ltd.....—
Agency—Rowlinson-Broughton.
Brooks & Walker Ltd.....—
Agency—Walter Judd Ltd.
Burgess Products Company Ltd.....—
Agency—Gee Advertising Ltd.
Burtonwood Engineering Co., Ltd....—
Agency—Stowe & Bowden Ltd.
Butterley Co., Ltd., The.....—
Agency—Scott-Turner & Assocs. Ltd.

Caldwell, T. & Son.....—
Castrep Co.....A65
Chapman & Hall Ltd.....487
Churchill Machine Tool Co., Ltd.....A40
Agency—Associated British Machine Tool Makers, Ltd.
Churchill, Chas. & Co., Ltd.....A91
Agency—Broadway Adv. Service Ltd.
Cincinnati Milling Machines Ltd.....A25
Agency—H. C. Longley Ltd.
Clayton-Wright, Howard, Ltd.....A90
Agency—G. Street & Co., Ltd.
Clifford, Chas., Ltd.....A87
Agency—Murray Watson Ltd.
Climax Molybdenum Company of Europe Ltd.....—
Agency—Rowlinson-Broughton.
Clough Engineering Co., Ltd.....—
Compoflex Co., Ltd.....A21
Agency—Technical & General Advertising Agency Ltd.
Connollys (Blackley) Ltd.....—
Agency—Ripley Preston & Co., Ltd.
Copper Development Association...A70
Agency—Technical & General Adv. Agency Ltd.
Cornelius Electronic Instruments Ltd. A84
Coseley Engineering Co., Ltd.....—
Agency—J. T. L. Advertising.
Coulthard, Wm. & Co., Ltd.....A70
Coventry Gauge & Tool Co., Ltd.....A52
Agency—Cogent Advertising Service Ltd.
Cronite Foundry Co., Ltd.....—
Crossley Bros., Ltd. & Crossley Premier Engines Ltd.....A90
Agency—Osborne Peacock Co., Ltd.
Curnon Engineering Co.....—
Curran, Edward, Engineering Ltd.....A1
Cushman & Denison Co., Ltd.....A76
Agency—Brockie, Haslam & Co.

Doncaster, Daniel & Sons Ltd.....A17
Agency—Rowlinson-Broughton.
Dowty Seals Ltd.....A19
Agency—Hamill Toms Ltd.
Dunlop Rubber Co., Ltd.....A6
Agency—Charles F. Higham Ltd.
Dunlop Special Products Ltd.....A51
Agency—Chas. F. Higham Ltd.

East Lancashire Chemical Co., Ltd....—
Agency—Stowe & Bowden Ltd.
E.M.B. Co., Ltd.....—
Electric Construction Co., Ltd.....—
Electro Dynamic Construction Co., Ltd.....A100
Agency—Armstrong-Warden Ltd.
Electro-Hydraulics Ltd.....—
Agency—John Newton (Publicity) Ltd.
Electro-Metal Deposits Ltd.....—
Electro-Platers Ltd.....A88
Agency—Sommerville & Milne Ltd.
Engineering Heat Treatments (Manchester) Ltd.....—
English Electric Co., Ltd.....A24
Agency—Service Advertising Co., Ltd.
Esso Petroleum Co., Ltd.....—
Agency—McCann Erickson Advertising Ltd.
Etchells, David & Sons Ltd.....A83
Etherow Engineering Co., Ltd.....—
Agency—Arthur Burns Publicity.

Ferguson, Pailin, Ltd.....—
Agency—Rowlinson-Broughton.
Ferodo Ltd.....A61
Agency—Armstrong-Warden Ltd.
Fibreglass Ltd.....A49
Agency—Cecil D. Notley Adv. Ltd.
Firkins, G. & A.....A92
Agency—Scott-Turner & Associates, Ltd.
Firth Brown Tools Ltd.....—
Agency—Stanley D. Dickson.
Firth, Thos. & John Brown Ltd.....A12
Agency—Stanley D. Dickson.
Fischer Bearings Co., Ltd.....—
Agency—H. Raymond Morgan.
Flame Hardeners Ltd.....—
Ford Motor Co., Ltd.....A39
Agency—Rumble, Crowther & Nicholas Ltd.
Fordsmith, H., Ltd.....A96
Francis, Wm. C., Ltd.....—
Fraser & Glass Ltd.....A33
Agency—Lambe & Robinson Ltd.

General Electric Co., Ltd.....A4 & A5
Gibbons Bros., Ltd.....—
Agency—Elliott Advertising Ltd.
Gittings & Hills, Ltd.....A66
Glacier Metal Co., Ltd., The.....A57
Agency—Cecil D. Notley Adv. Ltd.
Goodman, George, Ltd.....A59
Agency—Sterling Advertising Ltd.
Goodyear Tyre & Rubber Co., Ltd...A63
Agency—Erwin Wasey & Co., Ltd.
Grease Appliance Co.....A90 & A92
Agency—Arthur Burns Publicity.
Griffiths, A. E., Ltd.....A74
Agency—Clinton-Wall Publicity Ltd.
Guest, Keen & Nettlefolds Ltd.....—
Agency—Cecil D. Notley Adv. Ltd.
G.W.B. Electric Furnaces Ltd.....—
Agency—Crane Publicity Ltd.

Hackbridge & Hewittic Electric Co., Ltd. A38
Agency—Industrial Publicity Service Ltd.
Halden, J. & Co., Ltd.....—
Agency—Commercial Advertising Service Ltd.
Hall Harding Ltd.....A67
Hallamshire Steel & File Co., Ltd.....—
Agency—Downtons Ltd.
Hancock & Co. (Engineers) Ltd.....A89
Agency—Tibbenham Publicity Ltd.
Harcourt, David, Ltd.....A86
Agency—Allardyce Palmer Ltd.
Harris, John, Tools Ltd.....A66
Agency—Sinclair Advertising Agency.
Harpurhey Precision Engineers Ltd...A96
Agency—Arthur Burns Publicity.
Harvey & Longstaffe Ltd.....—
Agency—Cross-Courtenay Ltd.
Hayward, Tyler & Co., Ltd.....A27
Agency—Howards Publicity.
Heap, Joshua & Co., Ltd.....—
Heenan & Froude Ltd.....A18
Hercules Powder Co., Ltd.....—
Agency—Reynell & Son, Ltd.
Hilger & Watts Ltd.....—
Agency—Crane Publicity Ltd.
Holden, Arthur & Sons Ltd.....cover 2
Agency—S. D. Toon & Heath Ltd.
Holroyd, John & Co., Ltd.....A34
Agency—C. R. Casson Ltd.

Holt, James, Engineering (Sales) Ltd...A1
Agency—Arthur Burns Publicity.
Hoover Ltd.....—
Agency—Erwin Wasey & Co. Ltd.
Howard, Stanley, Ltd.....A35
Agency—Maurice G. Parker Ltd.
Humphreys, J. H. & Sons.....A85
Agency—Commercial Advertising Service Ltd.
Ilford Ltd.....A7
Agency—Samson, Clark & Co., Ltd.
Imhof, Alfred, Ltd.....A84
Industrial Fan & Heater Co., Ltd.....A48
Agency—Sinclair Advertising Agency.
International Combustion Ltd.....A15
Agency—Technical & General Adv. Agency Ltd.
International Meehanite Metal Co., Ltd. A54
Agency—Taylor Advertising Ltd.
Jones & Broadbent Ltd.....A93
Agency—Dixons West End Advertising Agency Ltd.
Jones, Tate & Co., Ltd.....—

Keelavite Rotary Pumps & Motors Ltd. .....—
Agency—Cogent Advertising Service Ltd.
Keeton, Sons & Co., Ltd.....A94
Agency—Downtons Ltd.
Kendall & Gent Ltd.....—
Agency—Associated British Machine Tool Makers, Ltd.
Kenyon, W. J. & Co. (Sheet Metal Workers) Ltd.....A74
Kirkham, J. & W., Ltd.....—

Lancashire Dynamo & Crypto Ltd....A95
Agency—John Mitchell & Partners Ltd.
Lang Pneumatic Ltd.....A79
Agency—Sterling Advertising Ltd.
Lee, Arthur & Sons Ltd.....A97
Agency—Cross Courtenay Ltd.
Lees & Sanders, Ltd.....—
Agency—White Adv.
Lewis & Tylor Ltd.....A50
Agency—Glovers Advertising Ltd.
Lewis Spring Co., Ltd.....488
Agency—Nicholls, Dorrity Adv. Ltd.
Ley's Malleable Castings Co., Ltd.....A56
Agency—H. Raymond Morgan.
Lincoln Electric Co., Ltd.....A11
Agency—London Press Exchange Ltd.
Lloyd, F. H. & Co., Ltd.....A37
Agency—Print for Industry Ltd.
London Office Machines Ltd.....—
Agency—Industrial Publicity Service Ltd.
Lubex Oil Refiners.....A90

Macrome Ltd.....A85
Agency—White Advertising.
Magnetic Valve Co., Ltd.....A77
Agency—Crane Publicity Ltd.
Massey, B. & S., Ltd.....A36
Agency—W. Hopwood & Co. Ltd.
Matterson Ltd.....A82
Agency—Matterson Advertising Ltd.
Mavitta Drafting Machines Ltd.....A86
Agency—John Haddon & Co. Ltd.
Metropolitan Vickers Electrical Co., Ltd. .....cover 1
Mining & Chemical Products Ltd.....A31
Minnesota Mining & Mfg. Co., Ltd....A75
Agency—Biddle Bros. (Advertising) Ltd.
Mond Nickel Co., Ltd.....A58
Agency—Technical & General Advertising Agency Ltd.
Moore & Wright (Sheffield) Ltd.....—
Morgan Crucible Co., Ltd.....—
Moulded Products Ltd.....—
Agency—L. Graham Browne Adv. Ltd.
Myford Engineering Co., Ltd.....A95

N.A.E.S. Ltd.....A81
Agency—Arthur Burns Publicity.
Neill, James & Co. (Sheffield) Ltd.....A83
Agency—J. K. Clayton Adv. Agency Ltd.
Newall, A. P. & Co., Ltd.....A45
Agency—Osborne-Peacock Co., Ltd.
Newall, Alexander S., Machine Tool Co., Ltd.....A9
Newall Group Sales Ltd.....A14
Agency—Rooster Publicity Ltd.
Newton, Chambers & Co., Ltd.....A68
Agency—Stanley D. Dickson.
Nitralloy Ltd.....A1
Northern Automatic Screw Co., Ltd...—
Agency—Ingham Butterworth Ltd.
Northern Scientific Equipment Ltd..A92

Oakey, John & Sons Ltd.....A84
Agency—Arthur S. Dixon Ltd.
Ozalid Co., Ltd.....A80
Agency—Clifton Adv. Agency Ltd.

Parker-Hale Ltd.....A88
Parsons Chain Co., Ltd.....—
Agency—Wilkes Bros. & Greenwood.
Payne & Griffiths Ltd.....A77
Agency—Sandbrook, Metcalf & Co., Ltd.
Permali Ltd.....A13
Agency—Glovers Advertising Ltd.
Perry Chain Co., Ltd..... A72
Agency—H. C. Longley Ltd.
Philips Electrical Ltd.....—
Agency—Erwin Wasey & Co., Ltd.
Pilkington Bros. Ltd.....A16
Agency—F. C. Pritchard Wood & Ptnrs. Ltd.
Pilot Works Ltd.....—
Agency—Rooster Publicity Ltd.
Pioneer Oilsealing & Moulding Co., Ltd. .....—
Agency—Hyde & Ptnrs. Ltd.
Pitman, Sir Isaac & Sons Ltd.....A47
Positive Lock Washer Co., Ltd.....—
Agency—Peter A. Menzies Advertising.
Power Jacks Ltd.....A79
Agency—John Mitchell & Partners Ltd.
Press Guards Ltd.....—
Agency—Rylee & Willington Ltd.
Projectile Engineering Co., Ltd.....A93
Agency—The Kingham Adv. Agency Ltd.

Radiant Metal Finishing Co., Ltd....A100
Agency—Pratt & Co. (Adv.) Ltd.
Raglan Eng. Co. (Nottm.) Ltd.....—
Agency—Rex Publicity Service Ltd.
Rapid Magnetic Co., Ltd.....—
Agency—Edward Hilton Adv. Ltd.
Ratcliffe, F. S. (Rochdale) Ltd.....—
Agency—Osborne-Peacock Co., Ltd.
Rawsthorne's (Bolton) Ltd.....A88
Redfern's Rubber Works Ltd.....—
Agency—Brockie, Haslam & Co.
Riley, Robert Ltd.....A94
Agency—Commercial Advertising Service Ltd.
Rudge Littley Ltd.....—

Salter, Geo. & Co., Ltd.....cover 3
Agency—Murray Watson Ltd.
Sanderson Bros. & Newbould Ltd....A42
Sandiacre Screw Co., Ltd.....—
Agency—Bemrose Publicity Co., Ltd.
Savery, T. A. & Co., Ltd.....A86
Schrader's, A., Son.....A29
Agency—Godbolds Ltd.
Sheffield Twist Drill & Steel Co., Ltd. A10
Smith, John (Keighley) Ltd.....A44
Agency—Heslock Ltd.
Smith, W. H. & Sons Ltd.....A67
South Wales Forgemasters Ltd.....A72
Agency—Maurice G. Parker Ltd.
Sparcatron Limited.....A8
Agency—E. Allan-Cooper & Co., Ltd.
Sparklets Ltd.....—
Agency—Basil Butler Co., Ltd.
Standard Telephones & Cables Ltd...A46
Agency—Brockie, Haslam & Co.
Steel, J. M. & Co., Ltd.....A82
Agency—Reynell & Son Ltd.
Super Oil Seals & Gaskets Ltd.....—
Agency—A. A. Black Ltd.
Sykes, W. E., Ltd.....A41
Agency—Gilbert Adv. Ltd.

Taylor, Taylor & Hobson, Ltd.....—
Agency—Pitchford Advertising Ltd.
Tecalemit Ltd.....A20
Agency—Armstrong-Warden Ltd.
Tempered Spring Co., Ltd.....—
Agency—Stowe & Bowden Ltd.
Thornton, A. G., Ltd.....A94
Agency—Baird & Dawson.
Tool Treatments (Chemicals) Ltd.....A84
Agency—Sinclair Adv. Agency.
Tufnol Ltd.....A73
Agency—Greenlys Ltd.
Tungum Co., Ltd.....A94
Agency—Hamill, Toms Ltd.
Turner, Ernest & Co. (Salford) Ltd...A96

Vaughan Crane Co., Ltd.....—
Vaughan, Edgar & Co., Ltd.....A23
Agency—Oldfield & Sharp.
Vickers-Armstrongs Ltd.....A80
Agency—Technical & General Adv. Agency Ltd.
Vickers-Armstrongs Ltd.....A53
Agency—John Mitchell & Partners Ltd.
Victa Engineering Co.....A96
Vokes Ltd.....A28
Agency—Crane Publicity Ltd.
Vulcascot (Gt. Britain) Ltd.....—

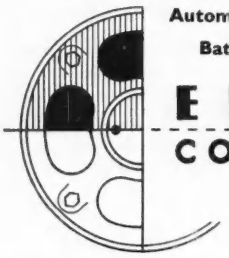
Wakefield, C. C. & Co., Ltd.....A55
Agency—Dorland Advertising Ltd.
Walker, Crosweller & Co., Ltd.....A64
Agency—Hamill Toms Ltd.
Watson Manasty & Co., Ltd.....—
Agency—R. S. Caplin Ltd.
Western Diecasting Ltd.....A95
Weston, Charles & Co., Ltd.....—
Agency—Rooster Publicity Ltd.
Whitehouse, Wm. & Co., Ltd.....A88
Wiggin, Henry & Co., Ltd.....A62
Agency—Technical & General Advertising Agency Ltd.
Wiseman, Alfred & Co., Ltd.....A78
Agency—Clifton Advertising Agency.
Wolverhampton Die Casting Co., Ltd. A78
Zinc Alloy Rust-Proofing Co., Ltd...A97

"Now thats our sort of job"

"We're not a mass production firm you know... and that's why we can be of special service to you. These machines you want will need some slight adaptation for your purpose; our Design Department can take care of that. As for production, we can also handle the medium runs you want at most economical prices. And you'll get good delivery, too. That's what I mean by 'our sort of job'!"

The "Electro Dynamic" range includes :—

Motors and Generators D/C. ¼ to 150 h.p.
Variable Speed Single Phase Motors
Automatic Control Gear
Battery Traction Motors



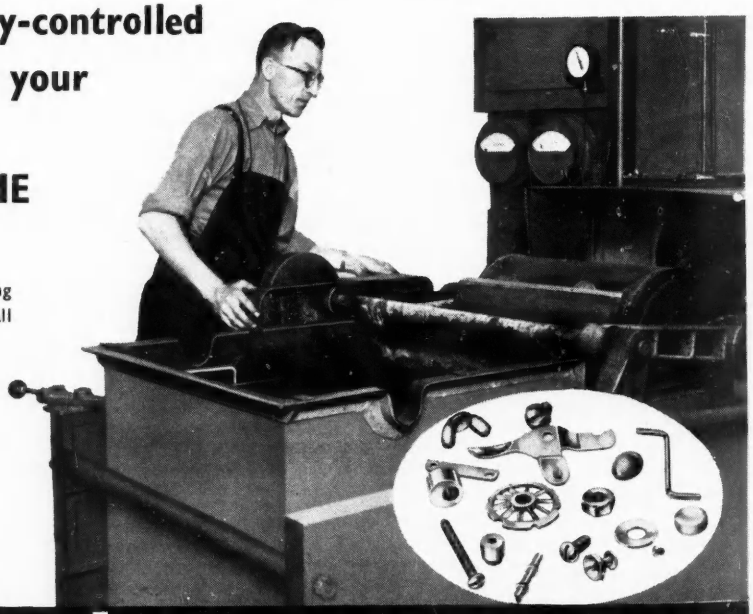
ELECTRO DYNAMIC CONSTRUCTION COMPANY LTD.

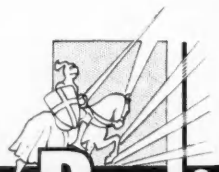
ST. MARY CRAY, KENT *Phone: Orpington 2560/3*

Switchgear Works. **BRIDGWATER, SOMERSET** *Phone: Bridgwater 2882*

Our Laboratory-controlled Works are at your disposal for BARREL CHROME

Competitive Prices for Plating of large quantities of small articles of similar shape and size.





Radiant METAL FINISHING CO. LTD.

WELLCHROME WORKS, SHEPHERDESS WALK, LONDON, N.1 *'Phone: CLErkenwell 2527-8-9 Branches: Wenlock Rd. N.1, Hackney E.9*

FOR EARLY DELIVERY

FROM AVAILABLE MATERIAL

Contact

SALTER

ABOUT SPRINGS & PRESSWORK

Est. 1760

Write for free copy of the Salter Spring Handbook—it's full of useful information

GEO. SALTER & CO. LTD., WEST BROMWICH **Telephone: West Bromwich 1331 (8 lines)**

LONDON Phone: Holborn 604617 MANCHESTER Phone: Blackfriars 8551 COVENTRY Phone: 3644

M.-W. 347

Easy to adjust
Simple in construction

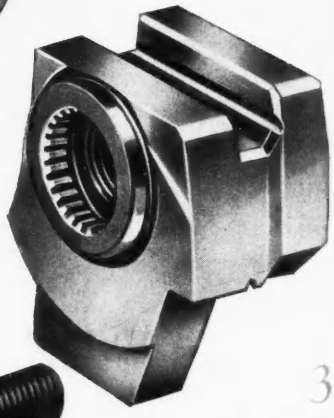
1

Circular Type Chasers on B.S.A. Namco Dieheads ensure extreme accuracy of thread form and long life. May be ground and re-ground through 270° of their circumference.

B.S.A.
NAMCO DIEHEADS

2

A double serrated bushing allows chaser to be set ahead a minimum amount to compensate grinding.



3

One piece hardened and ground chaser block into which fits serrated bushing (2) and locks the B.S.A. Namco long-life chaser (1)

Of most efficient yet simple design. Various types are available for use with stationary or revolving spindle, including the specially developed DBS head for use on single-spindle autos. Catalogue on request.

B.S.A. TOOLS LIMITED · BIRMINGHAM · ENGLAND

Sole Agents Gt. Britain: BURTON, GRIFFITHS & CO. LTD., *Small Tools Division,* **Birmingham, 11.** **Telephone VICTORIA 2351**